COMPARATIVE STUDIES OF THE ZOOBENTHOS OF A NATURAL AND A MAN-MADE ROCKY HABITAT ON THE EASTERN SHORE OF LAKE MICHIGAN

Diane D. Lauritsen

David S. White

Under contract with

American Electric Power Service Corporation

Indiana & Michigan Electric Company

Special Report No. 74 of the
Great Lakes Research Division

The University of Michigan
Ann Arbor, Michigan 48109

1981

ABSTRACT

A comparative study was conducted to examine differences and similarities between the benthic fauna of a naturally occurring rocky shoal habitat in the northern portion of Lake Michigan, Waugoshance Point, and the fauna associated with a man-made rocky riprap site at the Donald C. Cook Nuclear Power Plant in the southeastern part of the lake. Concrete substrate samplers were used as a method to quantify collections. The man-made riprap site and the rocky shoal site shared many of the same group of organisms, but differences between the sites were apparent, particularly in structure of the communities. The fauna of Waugoshance Point was dominated by filter-feeding organisms, whereas predators were most abundant at the Cook riprap location. Presence of Cladophora on the riprap is shown to be one of the most important factors accounting for the difference in densities and relative abundances of the fauna between the two sites. The Cladophora population created a habitat favorable to many types of benthic organisms, and their numbers dropped sharply with its disappearance from the riprap in late fall. The artificial substrates at Cook were colonized by species significantly different from the Ponar samples taken in adjacent unconsolidated sandy substrates, indicating the extent of change produced by the riprap in the otherwise featureless bottom.

ACKNOWLEDGMENTS

Appreciation is expressed to the personnel of Great Lakes Research Division of the University of Michigan for a wide variety of assistance and support with this project. John Cairns, Jr., Zenaida Catalan, John A. Dorr, III, and Michael Winnell read the manuscript and offered many helpful suggestions. Additional appreciation is expressed to John A. Dorr, III, for placement and retrieval of the samplers at the Cook Plant. The University of Michigan Biological Station, Pellston, Michigan, provided its facilities during the Waugoshance Point sampling periods.

Much of the data presented here was used as a thesis submitted to The University of Michigan in partial fulfillment of the requirements for the degree of Master of Science, Program in Water Resource Science.*

* Present address for Diane Lauritsen: Department of Zoology, North Carolina State University, Raleigh, North Carolina 27607.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

TABLE | Page

LIST OF FIGURES

INTRODUCTION

The general character of the benthic fauna in any given place is controlled by many factors, with the nature of the substrate being one of the most important. Lake substrates generally have been classified into the two basic types. Hard or consolidated primarily includes rock and gravel. Soft or unconsolidated is made up of mixtures of sand, mud, and silt. In Lake Michigan, most benthic sampling has been in the unconsolidated or soft sediment because it is dominant in the open waters of the lake. Virtually all benthic sampling in the Great Lakes is done with some type of grab sampler (Ponar, Ekman, Shipek, etc.) aboard a research vessel which, in turn, limits the depths that can be sampled to greater than 6-9 meters of water. The grabs also have limited the type of substrate that can be sampled, being very ineffective in the consolidated types.

While not usually a feature of the open lake, shallow areas with rocky bottoms are extensive in the Chicago area and along promontories of the western and northern shores of Lake Michigan (Ayers 1967). Artificial structures such as groins, jetties, and riprap extend the solid substrate and its associated benthic community throughout the lake, even in regions without naturally rocky bottoms (Herbst 1969). The intense concentration of zoobenthic life around the rocks, macrophytes, and other stable structures in the shallow waters of the lake remains among the least studied of the benthic communities (Mozley and Howmiller 1977). Solid substrates are known to support organisms much different from those in surrounding unconsolidated sediments (Shelford 1913, Krecker and Lancaster 1933, Shelford and Boesel 1942, Boscor and Judd 1972). Also of importance to the benthic community structure in many of these rocky

shallow areas is the water movement created by wave action or current associated with cooling water intakes and discharges. The conditions can create an idealized lotic habitat containing many organisms found in the "typical" stream (Shelford and Boesel 1942; Barton and Hynes 1978a, 1978b).

The more recent work on nearshore areas of Lake Michigan, including rocky habitats, has been connected with environmental monitoring at power plants. Rains and Clevenger (1975) found solid substrates to be colonized by attached algae and a diverse assemblage of Naididae (Oligochaeta) and Chironomidae (Diptera), often totaling more than 10,000 individuals per square meter. Installation of structures to protect and channel the intake and discharge of the Ludington Pumped Storage Plant created new substrate in an area of the lake characterized by a sandy bottom. The solid substrates were quickly colonized by a benthic assemblage that was quite different from that normally found in the area including Gammarus, Asellus, Physa, Trichoptera, and the chironomid genera Glyptotendipes, Thienemannimyia-gr., and Procladius. The indigenous community of the surrounding soft sediments was dominated by Pontoporeai hoyi and Tubificidae (Oligochaeta) (Olson 1974).

While the earlier rocky habitat surveys made use of a variety of techniques such as hand picking and dip-nets, more recent workers have employed an airlift system such as outlined by Barton and Hynes (1978a). The former methods suffered from obvious subjectivity and probable loss of many organisms, but in fact, none of the above-mentioned methods are truly quantitative. It is difficult to get an accurate measure of surface area at a rocky site, even with an airlift, as rocks may be only partially circumscribed by the quadrat boundary. Also, the quadrat method gives only an approximation based on the bottom area and not on the surface area of the rocks, which is a poor

indication of the area available for colonization by the benthic organisms; thus, it is not truly quantitative.

Another approach, the use of artificial substrates to quantify sampling, was decided on for this study. It was felt that this method would enable a greater degree of selectivity for those organisms actually associated with the rocky substrates, the premise of this study. Use of artificial substrates in rivers and streams is well documented and has undergone some standardization (Mason et al. 1967, Mason et al. 1973, Gale and Thompson 1974, Rabeni and Gibbs 1978), but there have been few studies using artificial substrate samplers directly in the Great Lakes with the exception of Olson's (1974) work at Ludington. Uniform-sized substrates can be mass produced with surfaces predetermined to obtain numbers of organisms (colonizing an artificial substrate sampler) per unit area. This is an estimate, then, of organisms in terms of available colonization space, and it should be a more consistent method of comparing different locations, particularly where the fauna is more characteristic of lotic habitats.

Most naturally occurring rocky shoals along eastern Lake Michigan proved not conducive to long-term artificial substrate studies, particularly on the southeastern shore. A preliminary zoobenthic survey at Waugoshance Point (Lauritsen, unpubl. data) indicated a stream-like community with large numbers of Hydropsychidae (Trichoptera), Ephemeroptera, and a filter-feeding Diptera Rheotanytarsus. It was felt that this naturally occurring rocky shoal site would serve as a comparison with the man-made rocky habitat created by the construction of the Donald C. Cook Nuclear Plant in the southeastern part of the lake, particularly if the substrates were made uniform through use of artificial samplers. Entrainment sampling and exploratory rock scrapings from

the riprap at the Cook Plant suggested that the riprap had been colonized by several taxa not indigenous to the surrounding lake bottom. Included in this group were species of Gammarus (Amphipoda), Cricotopus (Diptera), and Hydropsychidae (Trichoptera), (Mozley 1975, Mozley and Winnell 1975).

The main objectives of this study, then, were twofold: first, to attempt to quantify sampling in shallow, rocky habitats in Lake Michigan through the use of artificial substrate samplers; second, to use this information to compare the fauna of the D. C. Cook riprap habitat in the southeastern portion of the lake both with its surrounding soft sediment, and with a naturally occurring rocky shoal (Waugoshance Point).

DESCRIPTION OF STUDY SITES

The southern side of Waugoshance Point in the Sturgeon Bay area of northern Lake Michigan (Fig. 1) includes an extensive area of rocky, wave-swept shoals. Over much of this location are rocky patches alternating with sand bottom, the rocks ranging in size from a few centimeters to over 0.5 meters (Fig. 2). A heavy crust of marl covers the tops of many of the rocks. Water depth is variable because of the distribution of rocks, and in some areas rocky "islands" emerge from the water. Yearly fluctuations in lake levels have a great potential impact on the extent of rocky habitat available for benthic colonization in this area, e.g. the water level during 1978 was about 0.3 m lower than in the summer of 1975 creating a beach several meters wider (U.S. Department of the Army 1976, 1979.)

The Donald C. Cook Nuclear Plant is located on the southeastern shore of Lake Michigan, 16 km south of Benton Harbor, Michigan (Fig. 3). The plant is

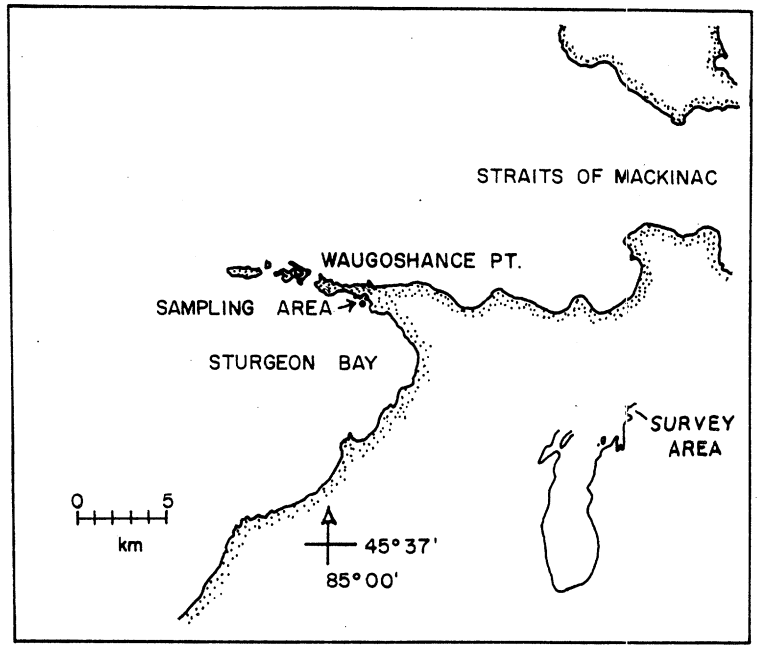

FIG. 1. The Sturgeon Bay region of Lake Michigan, showing Waugoshance Point and the sampling area where collecting was done in the summer of 1978.

FIG. 2. A, the study site on the southern side of Waugoshance Point. Sampler placement is denoted by the wooden stakes protruding from the water, which were used to anchor the baskets. B, close-up of sampler in place.

situated on an almost featureless, dune-lined shore, completely exposed to the prevailing westerly winds (Mozley 1974). Temperatures undergo wide fluctuations both seasonally and within periods of a few hours because of seiches, upwellings, and downwellings. Sediments range from coarse to medium and fine sands at depths of less than 12 m and are shifting continually along the shore (Mozley and Winnell 1975).

The general layout of the intake and discharge structures and the associated riprap is shown in Fig. 4. The light riprap or cover stone (2-68 kg rocks) forms an extensive portion of the substrate in this area, although in some areas the rocks are beginning to be buried by sand (J. Dorr, III, pers. comm.). In most years, the rocks support dense growths of *Cladophora* which reach maximum densities in late summer (Herbst 1969). Cooling water is drawn through three intake cribs located approximately 690 m offshore, in about 7 m of water. The intake cribs consist of rounded intake elbows (diameter of the intake pipes is 16 ft or 4.9 m) set in the lake bottom and surrounded by sacked concrete and light riprap to prevent erosion. Each elbow is completely surrounded by an octagonal heavy steel frame to prevent ice damage. There are bar racks and guides on the frame, which form an 20 x 20 cm grill to prevent large debris from entering the pipes, and the top of the frame has a plate steel roof to prevent floating objects from being sucked into the pipe. The entire structure, standing a little over 3 m high, creates many eddys and microcurrents along the bottom that would not normally exist in this portion of the lake in addition to the altered substrate.

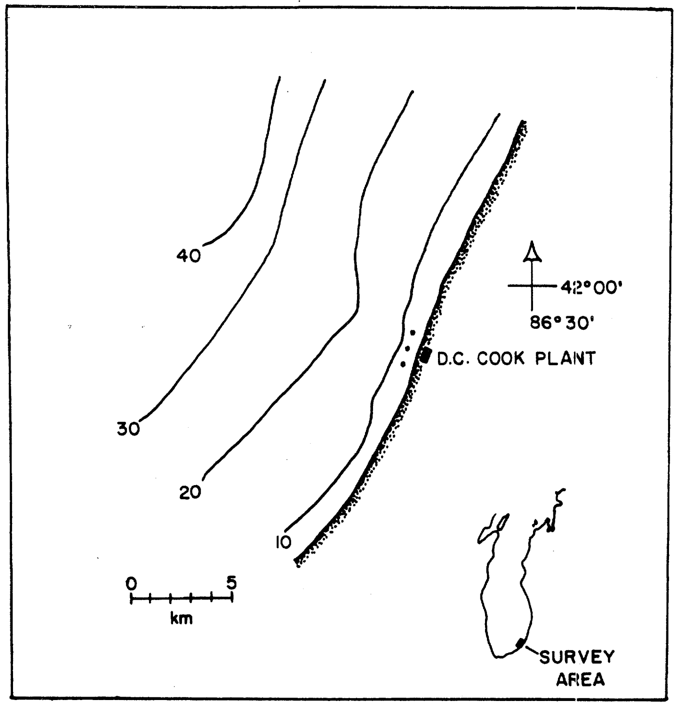

FIG. 3. Location of D. C. Cook Plant along the Lake Michigan shore and Ponar sampling stations (dots). Slightly modified from Mozley and Winnell (1975) (with permission).

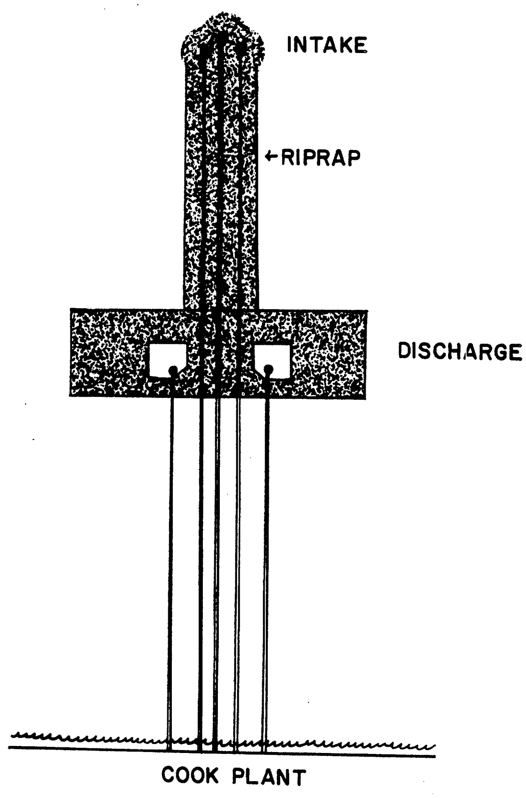

FIG. 4. Relative location of the intake and discharge structures and the associated riprap at the Cook Plant site.

METHODS

Artificial Substrate Samplers

Substrates were made by filling 0.47 L (4-oz) paper cups with Speed Crete Cement™ and peeling off the cups when the cement was dry. This type of artificial substrate has been used successfully in sampling in the Ohio River (S. Elbert, Univ. of Louisville, pers. comm.). Chicken barbecue baskets (Paramount Wire Products, Alhambra, Calif.) were used as sample holders, and six of the cement substrates were placed in each basket. Basket samplers were set in place at the Cook Plant location by divers. A rope was attached to the nearshore side of the southernmost intake crib (Fig. 4) to which the basket samplers were attached at approximately 2.5 to 3-m intervals. Ropes were attached to the samplers with a two-way clip, for easy attachment/detachment by the divers. Fig. 5 shows a basket sampler _in situ_. At Waugoshance Point, single basket samplers were anchored to wooden stakes driven into the sandy substrate underlying the rocks The samplers were placed in about 0.5 m of water.

Surface area of an individual substrate was determined to be 0.0226 m^2 and the total area per sampler would then be 0.0226 x 6, or 0.1358 m^2. Approximately 10% of this area was calculated as being unavailable for colonization because of the substrates being piled together. Thus the total available area per basket sampler was 0.1358 m^2 - 0.0136 m^2, or 0.1222 m^2, and the conversion factor (to a meter area) would be 8.1383.

Samplers were left in each location for about 2 months. Table 1 lists dates of sampler placement and retrieval at each site. Samplers were retrieved by placing each carefully in a drawstring bag made of silkscreen material (mesh size ca. 100 μ) before being removed from the bottom locations. Fig. 6 shows a

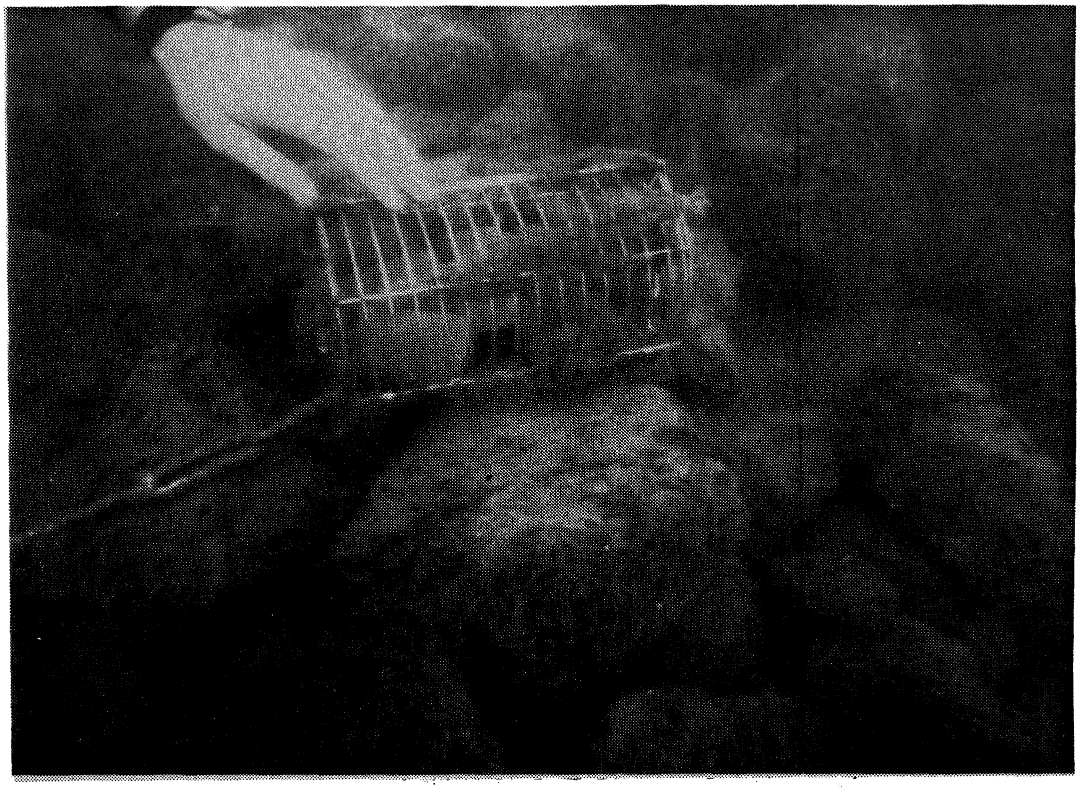

FIG. 5. Artificial substrate sampler _in situ_ at Cook riprap site.

FIG. 6. Divers placing basket sampler in retrieval bag.

TABLE 1. Dates of artificial substrate sampler placement and retrieval at the two sample sites in Lake Michigan during 1978.

Waugoshance Point	Placement	Retrieval
Areas A and B	5/28	7/19
Area C	6/22	8/9
Areas A and B	7/19	10/15
Area C	8/9	10/15
Cook Riprap		
Stations 1-11	6/12	8/10
Stations 12-14	6/12	10/22
Stations 1-11	8/10	10/22

basket sampler in a retrieval bag before being brought to the surface by the divers at the Cook site. Once out of the water, substrates from each basket were removed from the bags and placed in a fiberglass or plastic tub. The substrates were scrubbed gently with a brush and then rinsed thoroughly to remove all organisms. The retrieval bags also were rinsed into a tub to catch any organisms that had been dislodged during transport. The water containing the organisms was washed through a 250 μ mesh sieve and the residue placed in a Mason jar to which buffered 5% formalin was added.

In the laboratory, organisms were removed from the debris and sorted into major taxa with the aid of a dissecting microscope. Chironomidae and Oligochaeta were mounted on microscope slides using Amman's lactophenol and examined under 40X or greater magnification. Because of the large numbers of Rheotanytarsus collected at Waugoshance Point, it was found that reliable

identifications of the larger instars could be made with the use of the dissecting microscope without mounts.

Ponar Samples

Ponar samples were taken in August and October by Great Lakes Research Division personnel, in conjunction with monthly surveys as part of the environmental monitoring of the Cook Plant. Five one-third Ponar (Mozley and Chapelsky 1973) samples were taken at each station in August, and four full Ponars were taken in October. Data from three stations (Fig. 3) for August and October were chosen as corresponding to times of collection of the artificial substrate samplers. Each station was situated near the riprap at similar depths to the positioning of the rock baskets (6 m). Ponar samples were washed through a screen with 500 μ mesh openings, and the animals and residue were placed in Mason jars to which 5% buffered formalin was added as a preservative. Further details of benthic sampling and sample treatment at the D.C. Cook Plant can be found in Mozley (1975).

Nomenclature and Taxonomic Problems

As many problems still exist in identification of the major taxa in Lake Michigan, it was felt wise to list the taxonomic keys used: Oligochaeta, Hiltunen (1973); Chironomidae, Hamilton and Saether (pers. comm.), Hirvenoja (1973), Soponis (1977); Trichoptera, Ross (1944), Wiggins (1977), Schuster and Etnier (1978); Ephemeroptera, Burks (1953), Lewis (1974), Edmunds et al. (1976). Voucher specimens are on deposit with the Benthos Laboratory, Great Lakes Research Division, University of Michigan, Ann Arbor.

Species-level taxonomy for the chironomids is based on adult males. The larvae of most species are not positively identifiable in the immature state and must be reared to adults. The qualifier "cfr." meaning "near" is used in those instances where the larvae have not been reared to adults but fit a previously associated larval species type. Larval species association has been an ongoing feature of benthic sampling at the Cook Plant since 1974; consequently the chironomid fauna from the Ponar samples can be fairly well described. None of the chironomid larvae were reared from the Cook riprap and Waugoshance Point sites; therefore, most of the identifications from these samples could be made reliably only to genera or species groups.

Many of the early instars of Heptageniid are mayflies and Hydropsychidae caddisfly could not be identified reliably past the family level. Oftentimes even older specimens of Heptageniidae could not be taken to species level because of loss of gills or fading of abdominal coloration due to preservation of samples with formalin.

Two species of Gammaridae were identified from the riprap location: *Gammarus pseudobtusa* and *G. troglophilus*; however, it proved difficult to distinguish between the smaller specimens, so they are combined for purposes of data analysis.

Water Chemistry -- Waugoshance Point

Water temperatures were taken with a stem thermometer. pH was determined with a Hach Kit™ in August and with a Corning™ portable pH meter in October. Alkalinity was determined in accordance with Standard Methods (APHA 1975), and hardness was measured directly using an EDTA titriometric method (APHA 1975). Turbidity was measured as ppm SiO_2 using a Hellige Turbidimeter™. Dissolved

oxygen was determined according to the Altersberg (Azide) modification of the Winkler method (APHA 1975). Nutrient analysis was done at The University of Michigan with an A H 2 Technicon™ autoanalyzer.

Water Chemistry -- Cook Plant

R. Rossmann (Great Lakes Research Division) was kind enough to furnish unpublished chemical data obtained from the vicinity of the Cook Plant for April, May, and July 1978. Methodologies and treatment of water in these samples has been described in Ayers and Seibel (1973).

Statistical Methods

Sokal and Rohlf (1969) give a formula for determining the number of replicates needed to detect a given "true" difference between means. The formula can be transposed into the following:

$$\delta = \sigma \frac{2}{n} \left(t\alpha_{[\nu]} + t_{2(1-P)[\nu]}\right)$$

where σ is the standard deviation, δ is equal to the smallest true difference that it is desired to detect for a given sample size, *n* at a significance level α, with a probability *P* that the significance will found if it exists and where $t\alpha_{[\nu]}$ and $t_{2(1-P)[\nu]}$ are values from a two tailed t-table with ν degrees of freedom. This test was used to determine the "precision" of sampling with the number of replicates used in this survey.

Two measures were used to compare communities, the *coefficient of community* and *percentage similarity of community* (Jaccard 1932, Renkonen 1949, Kontkanen 1957, Whittaker 1952, Whittaker and Fairbanks 1958, Sanders 1960).

The coefficient of community (CC) determines the percentage of species shared by two samples:

$$CC = \frac{c}{a + b - c} \times 100$$

where $\underline{a}$ is the number of species in the first sample, $\underline{b}$ is the number of species in the second sample, and $\underline{c}$ is the number of species common to both. The percentage similarity of community (PSc) is a measure of the relative abundance of species the communities being compared:

$$PSc = 100 - 0.5 \left| a' - b' \right|,$$

where $\underline{a}'$ is the percentage of individuals of species $\underline{i}$ of the total individuals in the community $\underline{A}$, and $\underline{b}'$ the percentage of individuals of species $\underline{i}$ of the total individuals in the community $\underline{B}$. Thus, a high CC or PSc value (close to 100) would indicate a high degree of similarity between two communities.

The mean coefficient of community was calculated between replicates (ten comparisons were made at each site by choosing the replicates to be compared in a random fashion and calculating a mean from these ten CC values) to determine variability between replicates samples. A coefficient of community and percentage similarity value also was calculated between sampling dates at each site to make a temporal comparison at each site and between sampling sites for each month to directly compare the communities.

RESULTS

Water Chemistry

Chemical data from Waugoshance Point are presented in Table 2. Dissolved oxygen reached the highest saturation values measured in August. Among the pH values listed, the October value is probably the most accurate as a pH meter was used. It is doubtful that the pH would fluctuate to such a large degree in such a short time period and this is probably due to the coarser methodology of the Hach kit. Results from chemical analysis of lakewater in the vicinity of the Cook Plant are shown in Table 3. Dissolved oxygen levels are high, reaching supersaturation during some periods in the summer. In general, values for parameters at both sites are similar, at least for the particular sample dates.

TABLE 2. Water chemistry data for Waugoshance Point, Lake Michigan, 1978.

	AUGUST	OCTOBER
Dissolved oxygen	10.0 mg/L (112% sat.)	9.2 mg/L (73% sat.)
Water temperature	19°C	4.5°C
Hardness	137 mg/L $CaCO_3$	
Alkalinity	95 mg/L $CaCO_3$	97.5 mg/L $CaCO_3$
pH	8.7 (Hach kit)	7.85 (meter)
Turbidity	1.5 ppm SiO_2	
NO_3	26 ppb (N)	
NH_3	63 ppb (N)	
Cl	8.5 ppm	
total P	24 ppb	

TABLE 3. Water chemistry data (yearly averages and ranges) obtained in the vicinity of the D. C. Cook Nuclear Plant, 1978*.

Dissolved oxygen	88-120% saturation
Alkalinity	1.71-1.92 meq/L
pH	8.0
Soluble reactive PO_4-P	1.3 ppb
Soluble reactive SiO_2	0.31 ppm
SO_4^{2-}	20.0 ppm
Cl	11.0 ppm
Na	5.39 ppm
K	1.35 ppm
Ca	34.3 ppm
Mg	10.8 ppm

*Unpublished data, supplied by R. Rossmann, Great Lakes Research Division.

Zoobenthos -- Waugoshance Point

A total of 60 taxa was identified from Waugoshance Point (Table 4). Considering that some of the genera and other unidentified groups probably contain more than one species, this number is a conservative estimate. Total numbers of organisms were highest in July (1,959 m^{-2}) and lowest in October (1,923 m^{-2}) (Fig. 7). Appendices A and B list mean numbers of organisms, standard errors, and percentage of total animals for each sampling period.

Chironomidae, as a family, constituted the highest proportion of total animals in all sampling periods (Fig. 8), with the highest percentage (65%) occurring in October. The mean number of total Chironomidae in July

TABLE 4. Zoobenthic species collected from sites in Lake Michigan, July-October 1978.

Taxon	Waugo. Point	Cook Riprap	Cook Ponar
Coelenterata			
Hydroida			
Hydridae			
Hydra sp.	x	x	x
Clavidae			
Corydylophora lacustris Allman		x	
Platyhelminthes			
Turbellaria		x	x
Annelida			
Hirudinea			
Glossiphoniidae			
Helobdella stagnalis (Linnaeus)			x
Oligochaeta			
Aeolosomatidae		x	
Enchytraidae		x	
Lumbriculidae			
Stylodrilus heringianus Claparede		x	
Naididae			
Chaetogaster diaphanus (Gruithuisen)	x	x	x
Chaetogaster diastrophus (Gruithuisen)	x	x	
Dero sp.	x	x	
Nais alpena Sperber		x	
Nais behningi Michaelsen	x	x	
Nais bretscheri Michaelsen		x	
Nais elinguis Müller		x	
Nais simplex Piguet	x	x	
Nais variabilis (=*pardalis*) (Piguet)	x	x	x
undetermined *Nais* sp.		x	
Ophidonais serpentina (Müller)		x	
Piguetiella michiganensis Hiltunen			x
Pristina foreli (Piguet)	x		x
Pristina osborni (Walton)		x	
Specarina josinae (Vejdovsky)		x	x
Stylaria lacustris (Linnaeus)	x	x	x
Uncinais uncinata (Ørsted)			x
Vejdovskyella intermedia (Bretscher)	x	x	
Tubificidae			
Aulodrilus pluriseta (Piguet)			x
Limnodrilus augustipenis Brinkhurst & Cook			x
Limnodrilus cervix Brinkhurst			x
Limnodrilus hoffmeisteri (Walton)			x

(continued).

TABLE 4 (continued).

Taxon	Waugo. Point	Cook Riprap	Cook Ponar
Peloscolex freyi Brinkhurst			x
Potamothrix moldaviensis Vejdovsky and Mrazek			x
Potamothrix vejdovskyi (Hrabe)			x
Immature with hair chaetae		x	x
Immature without hair chaetae		x	x
Crustacea			
Amphipoda			
Gammaridae			
Gammarus pseudolimnaeus Bousfield		x	
Gammarus troglophilus Hubricht and Mackin	x		
Haustroriidae			
Pontoporeia hoyi Smith			x
Talitridae			
Hyalella azteca (Saussure)	x	x	x
Isopoda			
Asellidae			
Asellus sp.		x	
Hydracarina	x	x	x
Insecta			
Collembola	x		
Ephemeroptera			
Baetidae			
Baetis spp.	x		
Caenidae			
Caenis spp.	x		
Leptophlebiidae			
Paraleptophlebia sp.	x		
Heptageniidae			
Heptagenia juno McDunnough	x		
Heptagenia maculipennis Walshe	x		
Heptagenia pull (Clemens)		x	
undetermined *Heptagenia*	x	x	
Stenonoema puchellum (Walshe)		x	
Stenonoema tripunctatum (Banks)	x		
undetermined *Stenonema*	x	x	
Plecoptera			
Perlodidae			
Isoperla sp.	x		
Trichoptera			
Hydropsychiidae			
Cheumatopsyche sp.	x	x	

(continued).

TABLE 4 (continued).

Taxon	Waugo. Point	Cook Riprap	Cook Ponar
Symphitopsyche recurvata (Banks)	x	x	
Hydroptilidae			
Agraylea sp.	x	x	
Ithytrichia clavata	x		
Leptoceridae			
Ceraclea ancylus (Vorhies)	x		
Ceraclea sp. 2	x	x	
Mystacides spp.	x	x	
Triaenodes sp.		x	
Coleoptera			
Elmidae			
Dubiraphia vittata (Melsheimer)		x	
Dytiscidae			
Hydroporus sp.		x	
Hemiptera			
Salidae	x		
Diptera			
Empididae			
Hemerodromia sp.	x		
Chironomidae			
Chironomus anthracinus-group			x
Chironomus fluviatilis-group			x
undetermined *Chironomus* sp.		x	x
Cryptochironomus cfr. *rolli* (Kirpitshenko)			x
Cryptochironomus sp. 2			x
Cryptochironomus sp. 3			x
Demicryptochironomus sp.			x
Dicrotendipes sp.	x	x	
Endochironomus sp.	x		
Glyptotendipes sp.		x	
Parachironomus sp.	x	x	
Paracladopelma camptolabis-group			x
Paracladopelma cfr. *nereis* (Townes)		x	
Paracladopelma cfr. *undine* (Townes)			x
Phaenopsectra sp.	x		
Polypedilum cfr. *fallax* (Johannsen)	x		
Polypedilum cfr. *scalaenum* (Schrank)	x	x	x
Robackia cfr. *demeijeri* (Kruseman)			x
Saetheria cfr. *tylus* (Townes)		x	x
Stictochironomus sp. 1	x		
Stictochironomus sp. 2	x		
Cladotanytarsus sp.			x

(continued).

TABLE 4 continued.

Taxon	Waugo. Point	Cook Riprap	Cook Ponar
Micropsectra sp.	x	x	
Rheotanytarsus sp.	x	x	
Corynoneura sp.	x		
Cricotopus cfr. *bicinctus* (Meigen)	x	x	
Cricotopus *cylindraceus*-group	x		
Cricotopus *festivellus*-group	x	x	
undetermined *Cricotopus* (*Cricotopus*) sp.	x		
Cricotopus *intersectus*-group	x		
Heterotrissocladius cfr. *changi* Saether	x		x
Nanocladius sp.	x	x	
Orthocladius cfr. *robacki* Soponis	x		
undetermined *Orthocladius* (*Ortho.*) sp.	x		
Parakiefferiella sp.	x	x	
Psectrocladius cfr. *simulans* (Johannsen)	x	x	x
Synorthocladius sp.	x		
Thienemanniella sp.	x		
Monodiamesa cfr. *tuberculata* Saether		x	
Potthastia cfr. *longimanus* Kieffer			x
Nilotanypus sp.	x		
Thienemannimyia-group	x	x	
Nematoda	x	x	
Bryozoa	x	x	
Porifera			
Haplosclerina			
Spongillidae	x		
Tartigrada		x	
Mollusca			
Gastropoda			
Physidae			
Physella *integra* (Haldeman)	x		
Physella *vinosa* (Gould)		x	
Hydrobiidae			
Amnicola sp.			x
Somatogyrus sp.			x
Valvatidae			
Valvata *sincera* (Say)			x
Pelecypoda			
Sphaeriidae	x		
Pisidium sp.			x

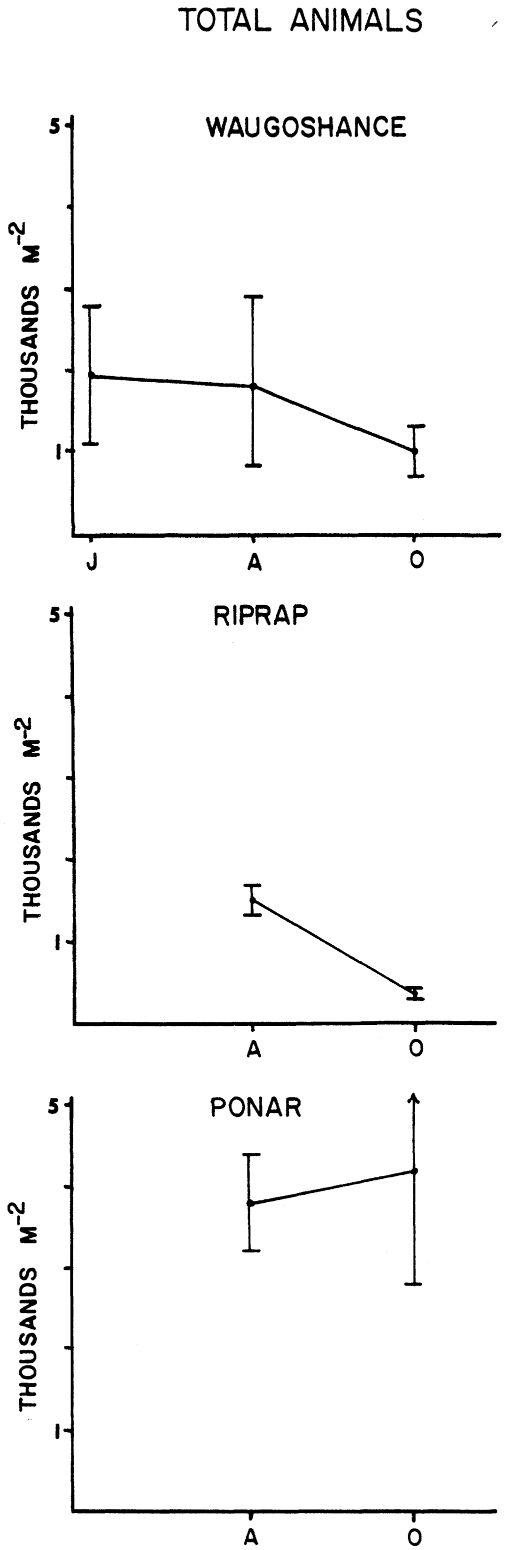

FIG. 7. Mean number of total organisms per square meter at each site for sampling dates in 1978. Standard errors are indicated by brackets. Hydra sp. are not included in Cook riprap totals; see text.

WAUGOSHANCE PT.

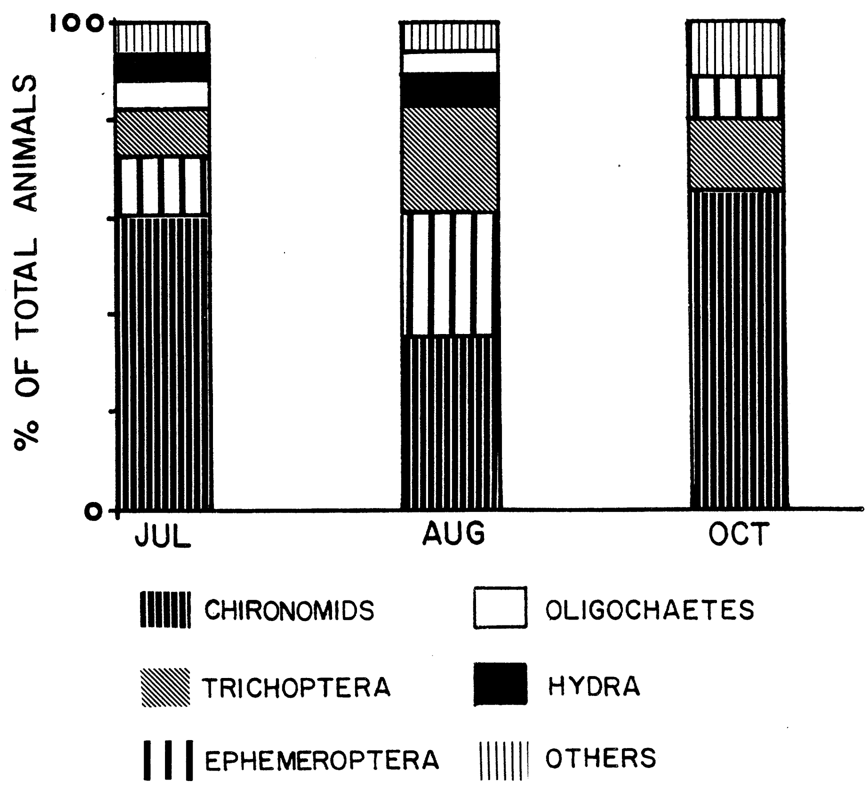

FIG. 8. Percentage of total organisms of each taxonomic group collected from Waugoshance Point during 1978.

(1,184 m^{-2}) was about twice that found in August (645 m^{-2}) (Fig. 9). Chironomids are also the most diverse group represented at Waugoshance Point with 26 identifiable taxa (Table 4). The greatest percentage of species was found within the subfamily Orthocladiinae (65%); however, many of these species were relatively rare. The subfamily Chironominae, tribe Tanytarsini, had the highest relative abundance, reaching almost 90% of total chironomids in October (Table 5). This is almost wholly due to the presence of _Rheotanytarsus_ larvae, by far the most abundant chironomid species present.

Trichoptera were found to be most abundant in August ($\overline{X}$ = 431 m^{-2}) (Fig. 10). Relative abundance as a percentage of total animals was also highest then (24%) (Fig. 8). Seven caddisflies taxa were found (Table 4), with _Cheumatopsyche_ spp. being most abundant. The highest relative abundance of _Cheumatopsyche_ was in August (83% of total Trichoptera), with October having the lowest (48%) (Table 6). Several _Cheumatopsyche_ pupae were collected in August and were the only Trichoptera pupae collected during this study.

The Oligochaeta fauna from the substrates at Waugoshance Point was comprised entirely of naidids, with seven species being found (Table 4). The mean density of oligochaetes was the highest in July (128 m^{-2}) and the lowest in October (25 m^{-2}) (Fig. 11). _Chaetogaster_ spp., _Stylaria lacustris_, and _Nais variabilis_ were the most abundant oligochaetes found in July and August, with _Chaetogaster_ spp. and _Nais simplex_ comprising the largest percentages of total oligochaetes in October (Table 7).

Ephemeroptera had the highest relative abundance as percent of total animals in August (25%) (Fig. 8); the mean density was also highest in this month (Fig. 12). The highest densities were due primarily to the large numbers of first instar _Baetis_ nymphs found in the August samples. Six taxa of

TABLE 5. Relative abundance of Chironomidae species as a percent of total Chironomidae at Waugoshance Point during July, August, and October 1978. Pupae and unidentified larvae are not included in the list.

Species	% of Total Chironomidae		
	July	August	October
Tanypodiinae			
Nilotanypus sp.			0.2
Thienemannimyia-group	4.2	6.8	2.5
Total Tanypodiinae	4.2	6.8	2.7
Tanytarsini			
Rheotanytarsus sp.	80.5	63.4	86.0
Micropsectra sp.	0.7		1.3
Total Tanytarsini	81.2	63.4	87.3
Chironomini			
Phaenopsectra sp.	0.6		0.3
Parachironomus sp.	<0.1	0.4	0.1
Polypedilum cfr. *fallax*		0.4	
Polypedilum cfr. *scalaenum*	1.2	2.1	3.9
Polypedilum sp. (undet.)		0.4	
Dicrotendipes sp.		0.4	0.2
Endochironomus sp.	0.7		0.6
Stictochironomus sp. 1			0.4
Stictochironomus sp. 2		0.4	
Microtendipes sp.	0.6	0.8	1.1
Total Chironomini	3.1	4.9	6.6
Orthocladiinae			
Corynoneura sp.	3.8	0.4	1.3
Cricotopus cfr. *bicinctus*	<0.1		
Cricotopus *cylindraceus*-group	0.3		
Cricotopus *festivellus*-group	0.6	2.9	0.5
Cricotopus *intersectus*-group	0.4	0.4	0.4
Cricotopus *tremulus*-group	0.4	5.5	0.1
Cricotopus sp. (undet.)	0.3	3.4	0.1
Heterotrissocladius cfr. *changi*	0.1		
Nanocladius sp.	1.4	4.6	0.3
Orthocladius cfr. *robacki*			0.2
Psectrocladius cfr. *simulaus*	0.6	4.2	
Parakiefferiella sp.			
Thienemannimyia sp.	0.3	0.4	
Synorthocladius sp.	0.2	0.4	0.3
Total Orthocladiinae	8.6	22.2	3.3

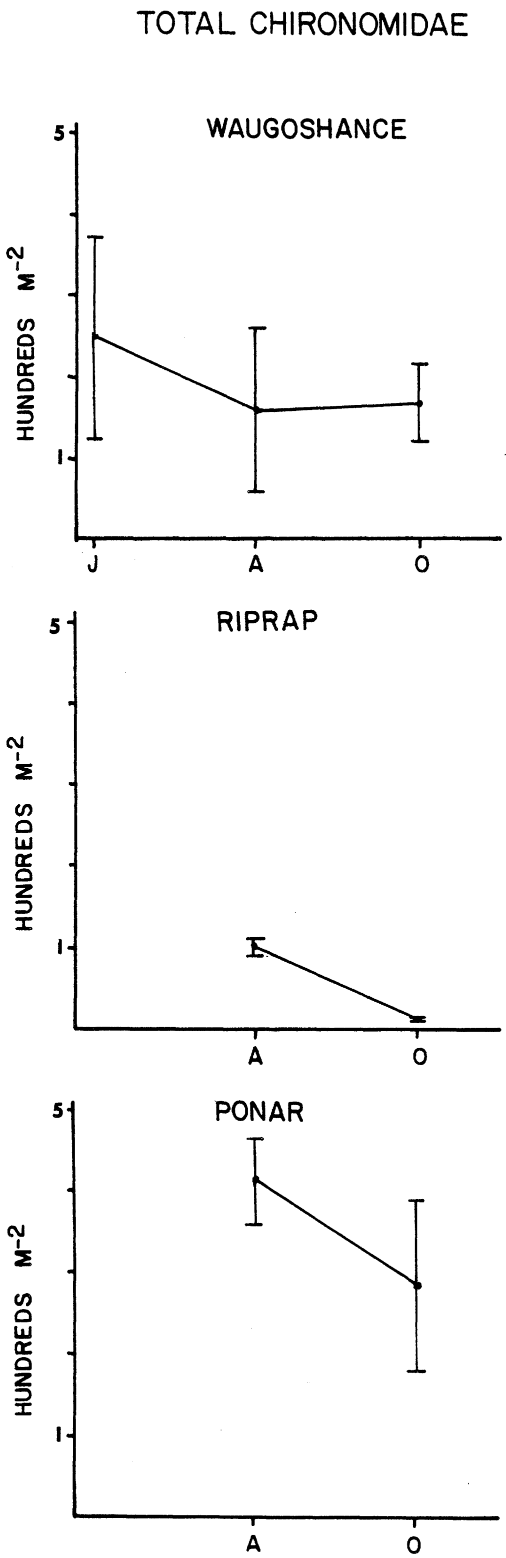

FIG. 9. Mean number of total Chironomidae per square meter at each site for sampling dates in 1978. Standard errors are indicated by brackets.

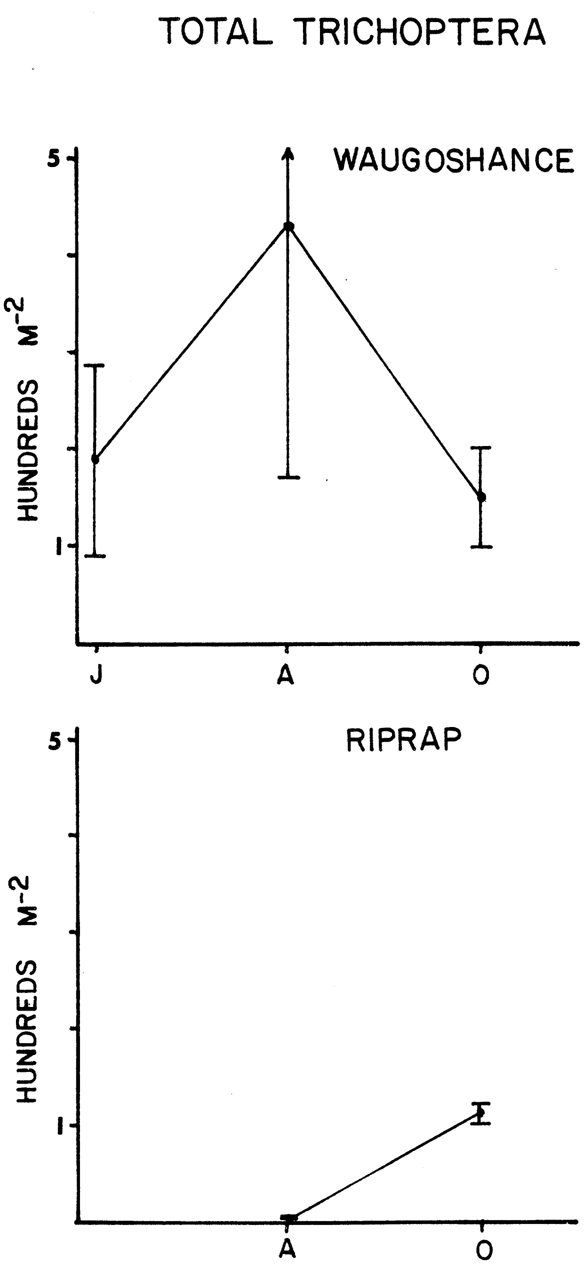

FIG. 10. Mean number of total Trichoptera per square meter at Waugoshance Point and Cook riprap for sampling dates in 1978. Standard errors are indicated by brackets.

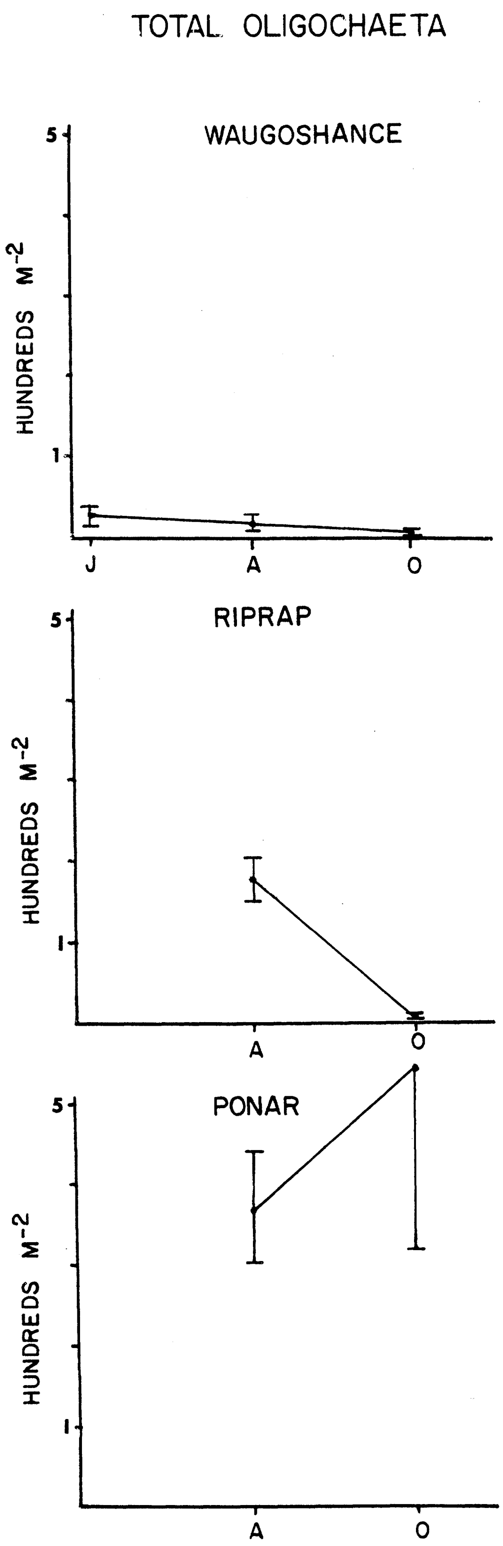

FIG. 11. Mean number of total Oligochaeta per square meter at each site for sampling dates in 1978. Standard errors are indicated by brackets.

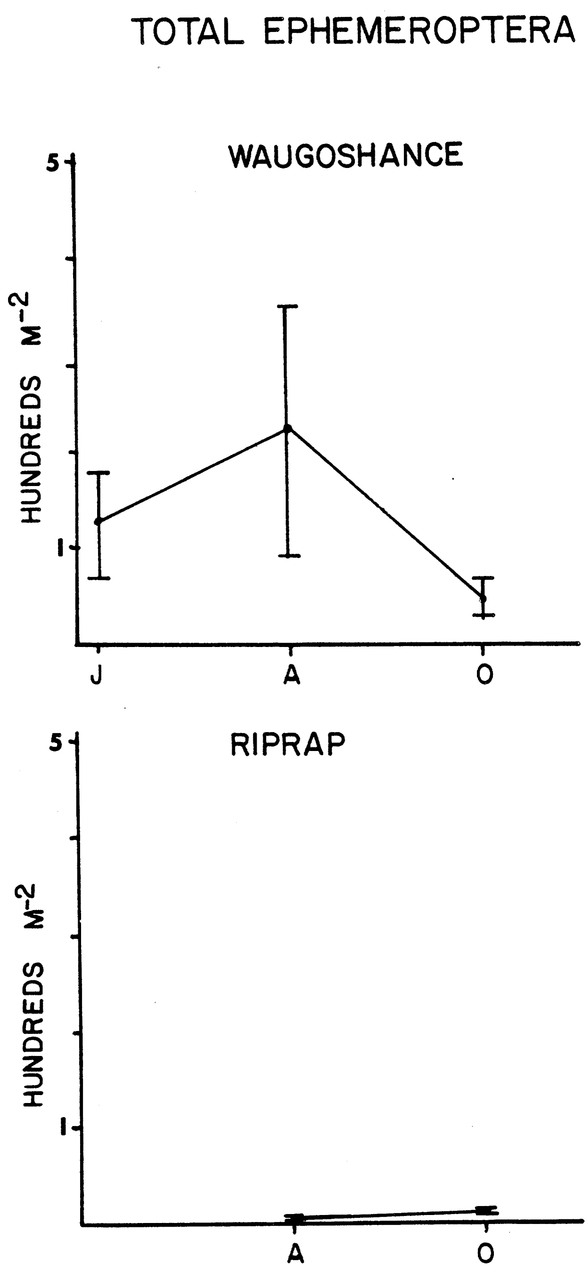

FIG. 12. Mean number of total Ephemeroptera per square meter at Waugoshance Point and Cook riprap for sampling dates in 1978. Standard errors are indicated by brackets.

TABLE 6. Relative abundance of Trichoptera species as a percent of total Trichoptera at Waugoshance Point during July, August, and October 1978.

Species	% of Total Trichoptera July	August	October
Cheumatophsyche sp.	56.6	83.5	48.1
Symphitopsyche recurvata	1.4		26.0
undet. Hydropsychiidae	38.5	6.9	22.5
Mystacides sp.	0.7		
Ceraclea sp.	0.7	0.6	0.4
Ceraclea ancylus			0.4
Agraylea sp.	0.7	5.7	2.7
Ithytrichia clavata	1.4		
undet. Hydroptilidae		3.2	

TABLE 7. Relative abundance of Oligochaeta species as a percent of total Oligochaeta at Waugoshance Point during July, August, and October 1978.

Species	% of Total Oligochaeta July	August	October
Naididae			
Chaetogaster spp.	17.0	25.1	58.1
Stylaria lacustris	31.8	53.8	6.8
Pristina foreli	3.1		2.4
Nais variabilis	25.7	10.6	9.3
Nais simplex	18.1	10.6	21.0
Nais behningi			2.4

Ephemeroptera were distinguishable, although *Paraleptophlebia*, *Caenis*, and *Baetis* probably included at least two species each, which would bring the total number of species found on the rocks to at least nine. *Baetis* was the most abundant Mayfly found in each sampling period, with the highest relative abundance occurring in July and in August (Table 8).

TABLE 8. Relative abundance of Ephemeroptera species as a percent of total Ephemeroptera at Waugoshance Point during July, August, and October 1978.

Species	% of Total Ephemeroptera		
	July	August	October
Heptagenia juno	7.3	0.6	4.0
Heptagenia maculipennis	1.0		
Heptagenia sp. (undet.)	1.0		11.8
Stenonema tripunctatum			4.8
Stenonema sp. (undet.)			2.6
undet. Heptageniidae	6.2	11.5	23.8
Paraleptophlebia sp.			9.8
Baetis sp.	84.5	87.3	42.8
Caenis sp.		0.6	0.7

Hydra (nr. *H. americanus*) was most abundant in July ($\overline{X}$ = 131 m^{-2}; 6.7% of total animals), and least abundant in October ($\overline{X}$ = 27 m^{-2}; 2.7% of total animals). *Hyalella azteca* was the only amphipod found, having the highest mean density in August (38 m^{-2}; 2.1% of total animals) and October (37 m^{-2}; 3.6% of total animals). The single species of snail (*Physella integra*) found had the highest mean density in August (46 m^{-2}; 2.5% of total animals). Hydracarina were most abundant in July ($\overline{X}$ = 11 m^{-2}; 0.5% of total animals).

Other organisms were found in very low densities in one sample or during a single sample period. Two very small stonefly nymphs of *Isoperla* were found in a single sample in October ($\overline{X}$ = 1 m^{-2}). Larvae of the empidid *Hemerodromia* (Diptera) also were found only in October ($\overline{X}$ = 5 m^{-2}) as were Corixidae (X = 1 m^{-2}). One Saldidae (Hemiptera) was found in July, resulting in a mean density of 1 m^{-2}, although not truly part of the benthos. Bryozoa (with statoblasts present) was found in some of the August samples (Appendix A). Often, when sand had collected in the basket sampler, Sphaeriidae and Nematoda

were found in the samples in low densities. The nematodes were not included in the data analysis as they were insufficiently sampled with the mesh size used in washing the samples. However, it is interesting to note that parasitic nematodes were found in *Rheotanytarsus* larvae in October. In some of the samples, from 2-20% of the *Rheotanytarsus* were infected.

Zoobenthos -- Cook Riprap

Sixty-one taxa were identified from the samplers placed at the Cook riprap, indicating a similar diversity to Waugoshance Point. The mean number of total organisms found in August (1,521 m^{-2}) was more than three times greater than that found in October (378 m^{-2}) (Fig. 7). Appendices C and D present information on mean density, standard errors, and percentage of total animals for all species for each sampling period.

Faunal composition was quite different in both sampling periods at this site (Fig. 13). In August, Oligochaeta were dominant, followed by Chironomidae and Hydracarina; in October, Trichoptera comprised the largest percentage of total animals, followed by Hydracarina, Amphipoda, Chironomidae, and Oligochaeta. However, the results shown by this figure must be qualified. *Hydra* sp. was actually the most abundant organism found in the samples at the riprap in August and October but impossible to quantify. Many of the budding structures had been broken off of the mature specimens, which would lead to inaccurate counts. *Hydra* were estimated in one sample with a density over 6,500 m^{-2}.

Chironomidae were more abundant in August ($\overline{X}$ = 405 m^{-2}) than in October ($\overline{X}$ = 46 m^{-2}) (Fig. 9). Eighteen species were found (Table 4), making this group the most diverse found at the riprap. The subfamily Chironominae

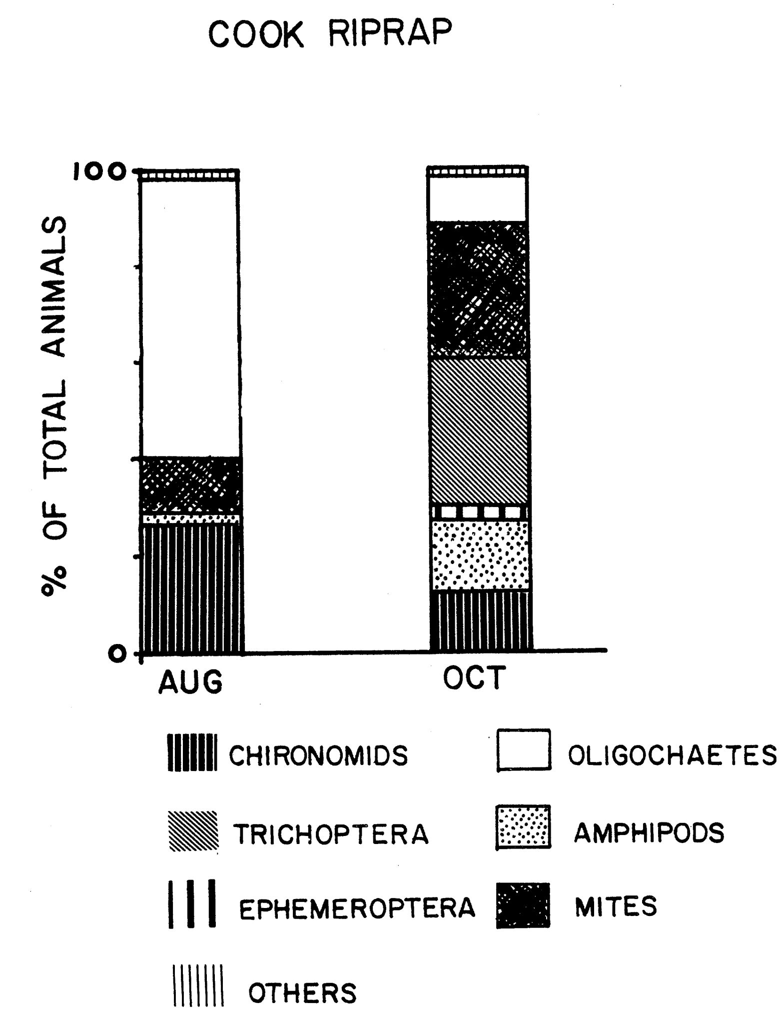

FIG. 13. Percentage of total organisms of each taxonomic group collected from Cook riprap during 1978.

contained the largest number of species (nine, or 50% of total) but the Orthocladiinae were well represented with eight species (44% of total). Table 9 lists the relative abundance of chironomid species for each sampling period. It can be see that the Orthocladiinae were overwhelmingly dominant in August (88% of total Chironomidae) because of very large numbers of _Psectorcladius simulans_. In October no _P. simulans_ were found, and the relative importance of other species increased. _Rheotanytarsus_ had the highest relative abundance

TABLE 9. Relative abundance of Chironomidae species as a percent of total Chironomidae at Cook riprap during August and October 1978. Pupae and unidentified larvae are not included.

Species	% of Total Chironomidae	
	August	October
Orthocladiinae		
Psectrocladius cfr. _simulans_	85.0	
Nanocladius sp.	1.1	6.3
Cricotopus cfr. _bicinctus_	1.1	5.0
Cricotopus festivellus-group	0.2	2.4
Cricotopus tremulus-group		1.3
Cricotopus sp.		5.0
Parakiefferiella sp.	0.2	3.7
Orthocladius sp.		1.3
Total Orthocladiinae	87.6	25.0
Chironomini		
Parachironomus sp.	1.3	3.7
Paracladopelma cfr. _nereis_	0.3	1.3
Polypedilum cfr. _scalaenum_	0.9	3.7
Saetheria cfr. _tylus_	2.0	5.0
Chironomus sp.	0.2	
Dicrotendipes sp.	0.3	10.0
Glyptotendipes sp.		1.3
Total Chironomini	5.0	25.0
Tanytarsini		
Rheotanytarsus sp.	0.5	30.3
Micropsectra sp.	0.2	6.3
Total Tanytarsini	0.7	36.6
Thienemannimyia-group	3.7	10.0

(30%) followed by Glyptotendipes and Thienemannimyia-gr., each with 10%.

Oligochaeta were found in higher densities in August ($\overline{X}$ = 886 m^{-2}) than in October (Fig. 11) with the October densities being quite low ($\overline{X}$ = 38 m^{-2}). A total of 17 species was found (Table 4), with the majority being Naididae. The most abundant oligochaetes found in August were Chaetogaster spp. including C. diastrophus and C. diaphanus (66% of total oligochaetes), followed by Nais variabilis (22%). In October, this order was reversed, with N. variabilis having the higher relative abundance (30% of total oligochaetes), Chaetogaster being second-most abundant (23%), and Aeolosomatidae being third (14%) (Table 10).

Trichoptera were found in much higher densities in October (X = 115 m^{-2}) than in August ($\overline{X}$ = 1 m^{-2}) (Fig. 10). Six different species were found (Table 4), but two forms of Symphitopsyche recurvata were distinguishable, one form with a very dark head coloration and one with a lighter (more normal?) head pattern coloration. It is not known whether these were variants or two different species. Only two species of Trichoptera were found in August, each with equally low densities, S. recurvata (lt.-form) and Triaenodes sp. (Table 11). The dark form of S. recurvata was most abundant in October (39% of total Trichoptera) with the light form being second-most abundant (28%).

Ephemeroptera were found in greater abundance in October ($\overline{X}$ = 14 m^{-2}) than in August ($\overline{X}$ = 3 m^{-2}) but in relatively low numbers at both periods (Fig. 12). Only two species were found (Table 4); many of the specimens were too young to make a positive identification. In August, only Stenonema puchellum was collected ($\overline{X}$ = 3 m^{-2}), and in October, Heptagenia sp. was most abundant ($\overline{X}$ = 7 m^{-2}; 52% of total Mayflies), followed by Stenonema sp. ($\overline{X}$ = 3 m^{-2}; 24% of total Mayflies).

TABLE 10. Relative abundance of Oligochaeta species as a percent of total Oligochaeta at Cook riprap during August and October 1978.

Species	% of Total Oligochaeta	
	August	October
Naididae		
Chaetogaster spp.	65.6	22.8
Dero sp.	0.2	
Nais alpena	0.2	
Nais behningi	0.2	
Nais bretscheri	2.7	7.6
Nais elinguis	<0.1	1.6
Nais simplex	0.8	
Nais variabilis	21.9	30.4
Nais sp. (undet.)		2.8
Ophidonais serpentina		1.6
Pristina osborni		2.8
Specarina josinae	0.6	
Stylaria lacustris	7.4	
Vejdovskyella intermedia	<1.0	
Total Naididae	99.9	69.6
Immature with hair chaetae		4.5
Immature without hair chaetae		6.0
Aeolosomatidae	<0.1	13.6
Enchytraidae		4.5
Lumbriculidae		
Stylodrilus heringianus		1.6

TABLE 11. Relative abundance of Trichoptera species as a percent of total Trichoptera at Cook riprap during August and October 1978.

Species	% of Total Trichoptera	
	August	October
Symphitopysche recurvata light form	50.0	28.2
Symphitopsyche recurvata dark form		39.3
Cheumatopsyche sp.		3.5
undet. Hydropsychiidae		9.6
Triaenodes sp.	50.0	
Mystacides sp.		0.5
Ceraclea sp. 1		6.0
Agraylea sp.		1.0

Amphipoda had similar mean abundances during August ($\overline{X}$ = 3 m^{-2}; 3.3% of total animals) and October ($\overline{X}$ = 59 m^{-2}; 11.1% of total animals). *Gammarus* spp. were the most abundant amphipod with *Hyalella azteca* being found only in August.

Hydracarina had the highest mean density in August ($\overline{X}$ = 166 m^{-2}) compared with 108 m^{-2} in October but had the highest relative abundance in October (28.5%) (Fig. 12). Other animals were found in low densities. *Asellus* sp. was more abundant in October ($\overline{X}$ = 10 m^{-2}); the Gastropod *Physella vinosa* was more abundant in August ($\overline{X}$ = 5 m^{-2}); and two Coleoptera, *Hydroporous* sp. and *Dubiraphia vittata*, were found only in October ($\overline{X}$ for both = <1 m^{-2}). The colonial organisms, Bryozoa and *Cordylophora lacustris*, were indicated in the tables only as present/absent in each sample. Bryozoa (statoblasts must be present in sample) was found in at least half of the samples from each sampling period, while *C. lacustris* was found only in October (see Appendices C and D).

Zoobenthos -- Cook Ponar

There was a total of 46 taxa identified in the Ponar samples at the 6-meter depth, with the majority of these being Chironomidae and Oligochaeta (Table 4). Mean numbers of total organisms were slightly higher in October (Fig. 7).

Oligochaeta was the most abundant group found in the Ponar samples (Fig. 14), having the highest relative abundance as a percentage of total animals in October (48%). Nine species of naididae and seven species of Tubificidae were collected, as well as the Lumbriculidae *Stylodrilus heringianus* and Enchytraidae. Naidids were the most abundant family of oligochaetes found at the 6-meter depth, comprising the largest percentage of total oligochaetes in October (83%). *Nais variabilis*, *Uncinais uncinata*, and

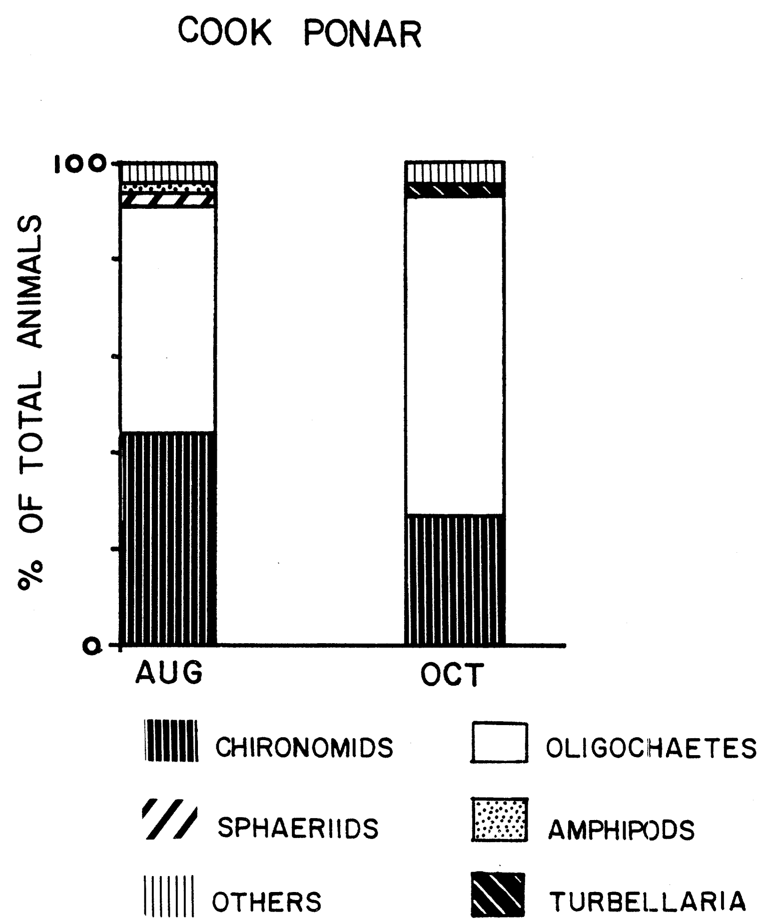

FIG. 14. Percentage of total organisms of each taxonomic group collected from Cook Ponar during 1978.

Piguetiella michiganensis were most numerous in August, comprising 14%, 21%, and 22% of total oligochaetes, respectively. In October, N. variabilis and P. michiganensis again were abundant, with each constituting 33% of total oligochaetes (Table 12). Tubificids, which were the second most abundant family, made up the greatest percentage of total oligochaetes in August (32%). Immature oligochaetes without hair chaetae were the dominant tubificids both in August (26% of the total oligochaetes) and October (15%) (Table 12). Stylodrilus heringianus contributed less than 1% of total oligochaetes in both August and October, while enchytraids were present only in October (<1% of total oligochaetes) (Table 12).

Chironomidae were the next most abundant group of zoobenthos, comprising the largest percentage of total animals in August (43%) (Fig. 14). Higher densities were also evident in that month ($\overline{X}$ = 1661 m^{-2}) (Fig. 9). Seventeen species of chironomids were collected from the Ponar samples, with the majority of species (72%) belonging to the subfamily Chironominae. This subfamily also was numerically dominant, comprising more than 90% of total chironomids during each sampling period (Table 13). The most abundant chironomid species found in August were Robackia demeijeri (23% of total chironomids), Saetheria tylus (19%), and Chironomus fluviatilis gr. (39%), while in October it was again Chironomus fluviatilis-gr. (46%) and Saetheria tylus (18%) (Table 13).

Other organisms were found in relatively low densities: Pontoporeia hoyi was the most abundant of the amphipods, having highest mean densities in August; Gammarus sp. was found only in August; and Hyalella azteca was found only in October. Species of the Sphaeriidae clam Pisidium were abundant in August, while Gastropoda, Hydracarina, Hirudinea, Turbellaria, and Hydra were most abundant in October (Appendices E and F).

TABLE 12. Relative abundance of Oligochaeta species as a percent of total Oligochaeta at Cook (Ponar) during August and October 1978.

Species	% of Total Oligochaeta	
	August	October
Naididae		
Chaetogaster spp.	2.2	4.6
Dero sp.		0.2
Nais variabilis	14.0	32.7
Piguetiella michiganensis	22.4	32.7
Pristina foreli		7.1
Specarina josinae	0.2	
Stylaria lacustris	7.2	0.7
Uncinais uncinata	21.0	4.6
Vejdovskyella intermedia	1.0	0.4
Total Naididae	67.9	82.8
Tubificidae		
Aulodrilus pluriseta	0.1	0.2
Limnodrilus augustipenis	0.2	
Limnodrilus cervix	<0.1	
Limnodrilus hoffmeisteri	0.4	
Peloscolex freyi	2.9	
Potamothrix moldaviensis	0.4	0.2
Potamothrix vejdovskyi		0.5
Immature without hair chaetae	1.6	0.7
Immature with hair chaetae	26.4	15.3
Total Tubificidae	32.0	16.8
Enchytraidae		0.2
Lumbriculidae		
Stylodrilus heringianus	<0.1	0.2

Statistical Comparisons

Results of the test for smallest true difference desired to detect with the sample sizes used in this survey are shown in Table 14. For comparative purposes, the δ values also are expressed as a percentage of the mean number of organisms at each site. The smallest true differences (δ) were found in the samples at the Cook riprap; and of the two sampling dates at this site, greatest precision was obtained in August. The δ values found at Waugoshance

TABLE 13. Relative abundance of Chironomidae as a percent of total Chironomidae at Cook (Ponar) during August and October 1978. Pupae and unidentified larvae are not included in the list.

Species	% of Total Chironomidae August	% of Total Chironomidae October
Orthocladiinae		
Heterotrissocladius cfr. *changi*	0.4	
Psectrocladius cfr. *simulans*	0.8	
Total Orthocladiinae	1.2	
Chironomini		
Cryptochironomus sp. 1	0.4	
Cryptochironomus sp. 2	2.8	3.0
Cryptochironomus sp. 3	1.1	11.8
Cryptochironomus cfr. *rolli*	<0.1	2.6
Demicryptochironomus sp.	0.2	
Chironomus anthracinus-gr.	2.5	
Chironomus *fluviatilis-gr*.	39.0	45.8
undet. *Chironomus* sp.	0.5	0.4
Polypedilum cfr. *scalaenum*	3.4	0.9
Saetheria cfr. *tylus*	19.2	17.9
Robackia cfr. *demeijeri*	22.8	9.2
Cladotanytarsus sp.	1.6	
Paracladopelma *camptolabis-gr*.	<0.1	7.0
Paracladopelma cfr. *undine*	1.1	
Total Chironomini	94.7	98.6
Diamesinae		
Monodiamesa cfr. *tuberculata*	0.3	
Potthastia cfr. *longimanus*		1.3
Total Diamesinae	0.3	1.3

Point were decreased by approximately one-half with every doubling of the number of replicates, but even with the largest sample size of 14, δ was quite high.

The results of the coefficient of community analysis between replicate samples for each sampling period is summarized in Table 15. The greatest variability at all three sample sites was found during the month of October. Table 16 shows the coefficient of community and percentage similarity results

TABLE 14. Smallest true difference (δ) desired to detect for a given sample size, for each sampling date at Cook riprap and Waugoshance Point locations. This difference (δ) is significant at the 5% level with a probability of 80% that the significance will be found if it exists.

Location	Month	n	δ	% of mean total animals
Cook Riprap	August	11	762.01	50.1
	October	14	210.33	55.6
Waugoshance Point	July	6	4183.63	213.5
	August	3	8080.08	447.1
	October	14	1327.44	129.7

TABLE 15. Mean coefficient of community (CC) between replicate samples for each sampling period at Cook and Waugoshance Point.

Location	Month	n	CC	SD
Waugoshance Point	July	6	45.8	46.9
	August	3	53.4	29.5
	October	14	40.6	41.1
Cook Riprap	August	11	45.7	46.6
	October	14	40.4	42.9
Cook Ponar	August	15	52.4	55.0
	October	12	36.4	37.9

TABLE 16. Coefficient of community (CC) and percentage similarity (PSc) values between months at each site and between sites for each month.

Location(s)	Month(s)	PSc	CC
Waugoshance Point	July-August	50.9	63.3
	August-October	51.1	48.3
	July-October	78.5	63.8
Cook Riprap	August-October	22.3	40.0
Cook Ponar	August-October	59.6	60.0
Cook Riprap & Ponar	August	17.9	19.7
	October	6.3	14.1
Waugoshance Point & Cook riprap	August	11.9	34.0
	October	18.9	29.9

between sampling dates and samping sites. The greatest correlation between sampling dates was found for Waugoshance Point July and October samples. At the Cook sampling sites, there was a greater variation between the riprap samples during August and October than with the Ponar samples taken during those months. In comparing the riprap and Ponar samples, it can be seen that the communities show the lowest degree of similarity in October, while comparisons between Waugoshance Point and the riprap had the highest percentage of similarity at that time.

DISCUSSION

Given the great degree of variability that may occur in bottom composition of a sampling site, artificial substrates offer one of the best methods currently available for comparative purposes between sites. Although this method does not provide an accurate assessment of actual standing crops found on the adjacent stream (or lake) bottom, it does provide a reasonably good estimate of relative abundance of the dominant groups (Hilsenhoff 1969, Mason et al. 1973).

Comparing the precision of the Cook riprap population estimates with those obtained at Waugoshance Point as shown by the smallest true difference test, it can be seen that even the use of the same number of samplers between the two sites does not give similar results, with the October value at Waugoshance Point being twice as high as that at the Cook riprap for the same date. The higher δ values obtained at Waugoshance Point indicate that this naturally occurring rocky habitat is much more varied in nature than the Cook riprap site. Because of variations in water depth, orientation of the rock surfaces to waves, etc., Waugoshance Point consists of a number of different types of microhabitats, and would require a substantially larger effort to obtain an accurate population estimate.

Although within site variability differs greatly between the two locations, this is not expressed by the coefficient of community comparisons. The mean CC values from Waugoshance Point and the Cook riprap are very similar, particularly in October, which indicates that the variability difference is based on numbers of organisms and not presence/absence of species in sample replicates. Barton and Hynes (1978b) have suggested that a small number of

replicates would be required to estimate percentage composition of the benthic fauna in rocky wave-zones of lakes. Results from the present survey indicate that the number of replicates required at a given rocky site is dependent upon the amount of habitat variability at a site, and an estimate of this variability should be obtained before a regular sampling program is begun.

Waugoshance Point Community

Certain physical and chemical factors suggest that the Waugoshance Point site can be functionally defined as a lotic habitat. These factors include shallowness, sunlight penetration to the bottom, wide fluctuations in water temperature with virtually no stratification, almost constant water movement, rocky substratum, and near to supersaturation levels of dissolved oxygen. Consequently, one may expect the benthic community found there to closely resemble that of a lotic community. The benthic fauna of lotic habitats with hard substrates has its own typical character and includes many obviously specialized forms (Hynes 1970). A great deal of the specialization results from specific food sources. Hard substrates support growths of attached algae and diatoms which are fed upon by the scrapers such as the mayflies *Heptagenia* and *Stenomema* and *Isoperla* stoneflies, or grazers such as *Physella*. Hard surfaces also support the capture nets of the net-spinning hydropsychid caddisflies and *Rheotanytarsus*, both abundant at Waugoshance Point, which utilize water movement to filter feed.

Another feature of Waugoshance Point was the presence of a marl crust up to 0.5 cm thick, covering the tops of rocks. Marl deposition may create an undesirable physical habitat for some forms of benthic organisms; snails were the only group observed on the marl crusts. Caddisfly nets and *Rheotanytarsus*

tubes were seen only on the bottoms of rocks where there was no marl. The above organisms had colonized all parts of the artificial substrates, including the tops. Marl may be unsuitable for certain forms of benthic colonization for several reasons: competition of marl-depositing algae with certain attached forms of benthos, the latter being excluded when tubes or nets become clogged (c.f. Wallner 1935); secretions of toxic compounds by marl-depositing algae which may inhibit certain types of benthic colonization; or, the physical nature of the marl itself which is not smooth or "stiff" enough to support attached benthic organisms (c.f. Minckley 1963). There are, however, certain benthic taxa, most notably the chironomid larvae *Lithotanytarsus* that are restricted to areas where travertine deposition occurs (Thienemann 1954).

The composition of the chironomid community at Waugoshance Point bears a notable resemblance to that found in streams. Most abundant were species in the subfamily Orthocladiinae. Orthoclad dominance seems to be a general feature of lotic chironomid communities (Thienemann 1941, Lehman 1971, Coffman 1973, Wiley 1976). Although the chironomid community at Waugoshance Point was rich in taxa, it was nonetheless dominated numerically by a few very abundant species, another demonstrated characteristic of Northern Michigan lotic communities (Wiley 1976). *Rheotanytarsus*, which comprised 63-86% of the total numbers of chironomids, is a filter-feeder common to solid substrates in running water. The top of the tube bears a number of outwardly splayed arms, between which the larvae spins strings of silk to catch passing particles (Hynes 1970). Most descriptions of *Rheotanytarsus* cases mention attachment to the substrate by a "stalk" with the entire case projecting up into the current (c.f. Walshe 1951). It is interesting to note that the *Rheotanytarsus* cases found at Waugoshance Point were attached horizontally to the rocks with no

visible "stalk" so the only part of the case above the rock was the arms. It is possible that the firmly attached type of case is an adaptation to a multidirectional current.

Cook Riprap Community

The Cook riprap site also shares certain physical features of a lotic nature, including water movement both from the cooling water intake and alongshore currents, rocky substratum, and near-to super-saturation levels of dissolved oxygen. Hydra, the most abundant organism at this site, favors hard surfaces for attachment and was probably assisted in capturing zooplankton by the intake currents (Batha 1974, Cuker 1978). In addition, dense growths of Cladophora became established on the rocks in summer, having disappeared by the time October samples were collected (J. Dorr III, pers. comm.). The presence of Cladophora can be seen to affect the total numbers of organisms found as well as faunal composition. It increases space available for attachment and clinging forms such as Naididae Oligochaeta, water mites (Hydracarina), and Amphipoda may reach large densities (Learner et al. 1978, Pennak 1978, Barton and Hynes 1976). These forms as well as the orthoclad Psectrocladius simulans dominated the fauna in August. P. simulans was found in relatively large densities in the sandy substrata further from shore (Wiley and Mozley 1978) so is probably plastic enough in substrate requirement to be able to utilize the habitat provided by Cladophora growth on the rocks.

With the disappearance of most of the Cladophora by October, the filter-feeding hydropsychid caddisflies and Rheotanytarsus became relatively more important components of the fauna. Water mites also increased in relative abundance although the mean number actually decreased. Psectrocladius simulans

was not found on October samplers from the Cook riprap or Ponars which suggests that the population may have emerged in the intervening time period.

Comparisons Between Communities -- Cook Riprap and Ponar

The fauna of the samplers from the riprap and the surrounding sandy substrate was quite different (Table 5). Burrowing forms of Oligochaeta and Chironomidae were dominant in the sand, whereas the Cook riprap and associated *Cladophora* growth supported attached and clinging forms. The community comparisons using coefficient of community and percentage similarity showed a relatively low correlation between the riprap and Ponar samples. The higher CC and PSc values found for August comparisons were due to the similarity of the Naididae fauna between the sand and the riprap.

Comparisons Between Communities -- Cook Riprap and Waugoshance Point

Not surprisingly, there was a greater degree of similarity between the Cook riprap fauna and the fauna of Waugoshance Point than between the riprap and the indigenous sand community. This affinity lies more in the number of shared species (as expressed by CC values) than similarity in relative abundances of shared species as expressed by PSc values. One of the most striking comparisons can be made regarding the basic structure of the riprap and Waugoshance communities. Filter feeding organisms were the dominant functional group at Waugoshance Point, whereas at the Cook riprap site predators dominate the fauna. The filter feeders at Waugoshance Point (*Rheotanytarsus* and hydropsychid caddisflies) build nets and tubes which serve not only to facilitate food collection but also to shelter them from adverse physical conditions such as severe wave action.

Although not directly tested, one might argue that Waugoshance Point is a physically controlled system, and that at the Cook riprap site, a modification of physical conditions primarily because of water depth allowed the development of an invertebrate predator-based community. However, many of the predators were dependent upon the "structure" provided by the Cladophora, and with its disappearance in October, filter-feeders gained in relative abundance.

Importance of Rocky Habitats

Rocky habitats in Lake Michigan offer a varied and abundant food resource for the fishes in these areas. Naturally occurring rocky shoals are known to be nursery grounds for young fish. For example, smallmouth bass spawn in and around Waugoshance Point (J. Gannon, pers. comm.).

Many of the organisms found in rocky habitats are sensitive to changes in water quality (e.g., Lewis 1974), fortuitously these areas are often located near shore (no ship time needed) or in an area where environmental monitoring is needed, such as power plant sites. The riprap organisms are being entrained by the Cook Plant (Mozley 1975), and efforts to gage the impact of the power plant should include more specific studies of the impact of entrainment on the riprap community.

SUMMARY

A greater degree of similarity was found between the Waugoshance Point benthic fauna and the Cook riprap fauna than between the Cook riprap and the indigenous fauna of the sandy substrates around the Cook Plant. The affinity between Waugoshance Point and the Cook riprap lies more in the number of shared species than similarity in relative abundances of shared species.

Waugoshance Point is an idealized lotic habitat, and this is evidenced by the benthic fauna found there. Filter feeders were the dominant functional group as they are in most streams. At the Cook riprap site, the kinds and numbers of organisms found depended upon the presence or absence of *Cladophora*. During the summer months when dense growths of *Cladophora* forms on the rocks, the benthic fauna was dominated by predatory attached and clinging forms that use the algae for support. With the disappearance of the *Cladophora* in late fall, the number of invertebrates found dropped sharply. The predator *Hydra* dominated the fauna during both sampling periods, and probably was utilizing the intake current of the power plant to assist in capturing prey.

The basket samplers with concrete substrates proved to work well and were easy to use at both locations. But the precision of sampling obtained with the samplers varied greatly between the two survey sites. The Cook riprap location was fairly uniform in physical condition, and this was indicated as well by the relatively small amount of variability between samples. Waugoshance Point, a naturally occurring shoal area, was a much more diverse physical habitat, and this was expressed by the great variation in numbers of organisms found between samples. Water depth and orientation of the rocks to wave action at Waugoshance Point also were much more variable. It may not be possible to reach the same degree of sampling precision as with the Cook Riprap site, but increasing the number of samples taken here would probably give a better idea of the amount of true variation between samples. It is suggested that any future survey work on rocky shoal areas in the Laurentian Great Lakes include a preliminary determination of habitat variability before a regular sampling program is begun, with the number of samples to be taken reflecting this variability.

LITERATURE CITED

(APHA) American Public Health Association. 1975. Standard methods for the examination of water and wastewater, 14th ed. American Public Health Association, New York.

Ayers, J. C. 1967. The surficial bottom sediments of Lake Michigan. In: J. C. Ayers and D. C. Chandler (eds.), Studies on the environment and eutrophication of Lake Michigan. Univ. Michigan, Great Lakes Res. Div. Spec. Rept. 30. pp. 247-253.

Ayers, J. C., and E. Seibel. 1973. Program of aquatic studies related to the Donald C. Cook Nuclear Plant. Great Lakes Research Division Special Report 44, Part 17. 57 pp.

Barton, D. R., and H. B. N. Hynes. 1976. The distribution of Amphipoda and Isopoda on the exposed shores of the Great Lakes. J. Great Lakes Res. 2: 207-214.

Barton, D. R., and H. B. N. Hynes. 1978a. Wave-zone macrobenthos of the exposed Canadian shores of the St. Lawrence Great Lakes. J. Great Lakes Res. 4: 27-45.

Barton, D. R., and H. B. N. Hynes. 1978b. Seasonal study of fauna of bedrock substrates in the wave-zone of Lakes Huron and Erie. Can. J. Zool. 56: 48-54.

Batha, J. V. 1974. The distribution and ecology of the genus Hydra in the Milwaukee area of Lake Michigan. Unpublished Ph.D. thesis, Univ. of Wisconsin, Milwaukee.

Boscor, J. G., and J. H. Judd. 1972. Effect of paper plant pollution and subsequent abatement on a littoral macroinvertebrate community in Lake Ontario: preliminary survey. Proc. 15th Conf. Great Lakes Res., Internat. Assoc. Great Lakes Res. pp. 21-34.

Burks, B. D. 1953. The Mayflies, or Ephemeroptera, of Illinois. Ill. Nat. Hist. Surv. Bull. 26. 216 pp.

Coffman, W. P. 1973. Energy flow in a woodland stream ecosystem: II. The taxonomic composition and phenology of the Chironomidae as determined by the collection of pupal exuviae. Arch. Hydrobiol. 71: 281-322.

Cuker, B. E. 1978. Ecology of Hydra in an arctic Alaskan lake. Unpublished M.S. thesis, Univ. of Michigan, Ann Arbor.

Edmunds, G. F., Jr., S. L. Jensen, and L. Berner. 1976. The mayflies of North and Central America. Univ. Minnesota Press, Minneapolis. 330 pp.

Gale, W. F., and J. D. Thompson. 1974. Placement and retrieval of artificial substrate samplers by SCUBA. Prog. Fish Cult. 36: 231-236.

Herbst, R. D. 1969. Ecological factors and the distribution of Cladophora glomerata in the Great Lakes. Am. Midl. Nat. 82: 90-98.

Hilsenhoff, W. L. 1969. An artificial substrate device for sampling benthic stream invertebrates. Limnol. Oceanogr. 14: 465-471.

Hiltunen, J. K. 1973. A laboratory guide. Key to the tubificid and naidid Oligochaeta of the Great Lakes region. Great Lakes Fishery Laboratory, Ann Arbor, Michigan. 24 pp. (mimeo).

Hirvenoja, M. 1973. Revision der Gattung Cricotopus van der Wulp und ihrer Verwandten (Diptera: Chironomidae). Ann. Zool. Fenn. 10: 1-363.

Hynes, H. B. N. 1970. The ecology of running waters. Univ. Toronto Press, Toronto. 555 pp.

Jaccard, P. 1932. Die statistisch-florestische Methode als Grundlage der Pflanzen-soziolígie. Handb. Biol. Arbeitsmeth. 5: 165-202.

Kontkanen, P. 1957. On the delimitation of communities in research on animal biocoenotics. Cold Spring Harbor Symp. Quant. Bio. 22: 373-378.

Krecker, F. H., and L. Y. Lancaster. 1933. Bottom shore fauna of Western Lake Erie: a population study of a depth of six feet. Ecology, 14: 79-93.

Learner, M. A., G. Lochhead, and B. D. Hughes. 1978. A review of the biology of British Naididae (Oligochaeta) with emphasis on the lotic environment. Freshwat. Biol. 8: 357-375.

Lehman, J. 1971. Die Chironomiden der Fulda. Arch. Hydrobiol. Suppl. 37: 466-555.

Lewis, P. A. 1974. Taxonomy and ecology of Stenonema mayflies (Heptageniidae: Ephemeroptera). U.S. Environmental Protection Agency, Environmental Monitoring Ser. Rept. EPA-670/4-74-006. 81 pp.

Mason, W. T., Jr., J. B. Anderson, and G. E. Morrison. 1967. Limestone-stone-filled, artificial substrate sampler. Float unit for collecting macroinvertebrates in large streams. Prog. Fish Cult. 29: 74.

Mason, W. T., Jr., C. I. Weber, P. A. Lewis, and E. C. Julian. 1973. Factors affecting the performance of basket and multiplate macroinvertebrate samplers. Freshwat. Biol. 3: 409-436.

Minkley, W. L. 1963. The ecology of a spring stream Doe Run, Meade County, Kentucky. Wildl. Monogr. Chestertown, II, 124 pp.

Mozley, S. C., and O. Chapelsky. 1973. A ponar grab modified to take three samples in one cast with notes on ponar construction. Proc. 16th Conf. Great Lakes Res., pp. 97-99. Internat. Assoc. Great Lakes Res.

_______. 1974. Preoperational distribution of benthic macroinvertebrates in Lake Michigan near the Cook nuclear power plant. In: E. Seibel and J. C. Ayers, The biological, chemical, and physical character of Lake Michigan in the vicinity of the Donald C. Cook Nuclear Plant. Univ. Michigan, Great Lakes Res. Div. Spec. Rept. 51. pp. 5-137.

_______. 1975. Preoperational investigations of zoobenthos in southeastern Lake Michigan near the Cook nuclear plant. Univ. Michigan, Great Lakes Res. Div. Spec. Rept. 56. 132 pp.

_______, and M. H. Winnell. 1975. Macrozoobenthic species assemblages of southeastern Lake Michigan, U.S.A. Verh. Internat. Verein. Limnol. 19: 922-931.

_______, and R. P. Howmiller. 1977. Zoobenthos of Lake Michigan. Vol. 6. In: Environmental status of the Lake Michigan region, Argonne National Laboratory. 148 pp.

Olson, G. R. 1974. The benthic macroinvertebrate populations in a new pumped storage reservoir and the adjacent coastal areas of central Lake Michigan. Unpublished M. S. thesis, Michigan State Univ., East Lansing.

Pennak, R. W. 1978. Fresh-water invertebrates of the United States. John Wiley and Sons, New York. 803 pp.

Rabeni, C. F., and K. E. Gibbs. 1978. Comparison of two methods used by divers for sampling benthic invertebrates in deep rivers. J. Fish. Res. Bd. Can. 35: 332-336.

Rains, J. H., and T. B. Clevenger. 1975. Benthos, Chapter 8. In: Industrial Bio-Test Laboratories, Inc., Operational environmental monitoring program of Lake Michigan near the Kewaunee Nuclear Power Plant. Chemical and biological studies, January-December 1974. Report to Wisconsin Public Service Corp., Green Bay, Wisc.

Renkonen, O. 1949. Discussion on the ways of insect synecology. Oikos 1: 122-126.

Ross, H. H. 1944. The caddisflies or Trichoptera of Illinois. Illinois Nat. Hist. Surv. Bull. Vol. 23, # 1. 326 pp.

Sanders, H. L. 1960. Benthic studies in Buzzards Bay. III. The structure of the soft bottom community. Limnol. Oceanogr. 5: 138-153.

Schuster, G. A., and D. A. Etnier. 1978. A manual for the identification of the larvae of the caddisfly genera Hydropsyche Pictet and Symphitopsyche Ulmer in Eastern and Central North America (Trichoptera: Hydropsychidae). U.S. Environmental Protection Agency, Environmental Monitoring Ser. Rept. EPA-600/4-78-006. 128 pp.

Shelford, V. E. 1913. Animal communities in temperate America (as illustrated in the Chicago region). Geogr. Soc. Chicago Bull. 5: 1-363.

Shelford, V. E., and M. W. Boesel. 1942. Bottom animal communities of the island area of Western Lake Erie in the summer of 1937. Ohio J. Sci., 42: 179-190.

Sokal, R. R., and F. J. Rohlf. 1969. Biometry. W. H. Freeman and Company, San Francisco. 776 pp.

Soponis, A. R. 1977. A revision of the nearctic species of Orthocladius (Orthocladius) van der Wulp (Diptera: Chironomidae). Men. Ent. Soc. Can. 187 pp.

Thienemann, A. 1941. Lapplandische Chironomiden und ihre Wohngewasser. Arch. Hydrobiol. Suppl. 17: 1-253.

Thienemann, A. 1954. Chironomus. Die Binnengewasser. 20: 1-834.

U.S. Department of the Army. 1976, 1979. Monthly bulletin of lake levels for the Great Lakes. Corps of Engineers, Detroit District.

Wallner. 1935. Beih. Bot. Centralbl. 54, Abt. A, 142-150. (In Thienemann, 1954, title not found.)

Walshe, B. M. 1951. The feeding habits of certain chironomid larvae (subfamily Tendipedinae). Proc. Zool. Soc. Lond. 121: 63-79.

Whittaker, R. H. 1952. A study of summer foliage insect communities in the Great Smokey Mountains. Ecol. Monogr. 22: 6-31.

Whittaker, R. H., and C. W. Fairbanks. 1958. A study of plankton and Copepod communities in the Colombia Basin, southeastern Washington. Ecology, 39: 46-65.

Wiggins, G. B. 1977. Larvae of the North American caddisfly genera (Trichoptera). Univ. Toronto Press, Toronto.

Wiley, M. J. 1976. The ecology of the chironomid community (Diptera: Chironomidae) of Hunt Creek with special reference to substrate relations. Unpublished M.S. thesis, Univ. of Michigan, Ann Arbor.

________, and S. C. Mozley. 1978. Pelagic occurrence of benthic animals near shore in Lake Michigan. J. Great Lakes Res. 4: 201-205.

APPENDIX A. Numbers of organisms per square meter for each sample at Waugoshance Point in July and August, 1978. Mean, standard error, and % of total animals is given for each taxon.

Taxon	July									August					
	A-1	A-2	A-3	B-1	B-2	B-3	$\overline{X}$	S.E.	% T.A.	C-5	C-4	C-2	$\overline{X}$	S.E.	% T.A.
CHIRONOMIDAE															
Thienemannimyla-gr.	65	33	57	74	49	24	50.3	21.7	2.6	8	82	41	43.7	30.7	2.4
Rheotanytarsus sp.	1677	687	703	1104	728	818	952.8	414.9	48.6	221	589	417	409.0	251.6	22.6
Micropsectra sp.	41			8			8.2	6.9	0.4						
Phaenopsectra sp.	24					16	6.7	4.8	0.3						
Parachironomus sp.		8					1.3	1.3	<0.1		8		2.7	1.9	0.1
Polypedilum fallax												8	2.7	1.9	0.1
Polypedilum scalaenum	8	16		41	8	16	14.8	8.0	0.7			41	13.7	13.7	0.8
Polypedilum sp.											8		2.7	1.9	0.1
Dicrotendipes sp.											8		2.7	1.9	0.1
Endochironomus sp.		8		16	24		8.0	5.0	0.4						
Stictochironomus sp. 2												8	2.7	1.9	0.1
Microtendipes sp.						41	6.8	6.8	0.3	8		8	5.3	3.7	0.3
Corynoneura sp.	33	57	24	82	57	16	44.8	20.5	2.3		8		2.7	1.9	0.1
Cricotopus bicinctus	8						1.3	1.3	<0.1						
Cricotopus cylindraceus-gr.				16		8	4.0	3.0	0.2						
Cricotopus festivellus-gr.	8			8		24	6.7	4.4	0.3	16	33	8	19.0	12.5	1.0
Cricotopus intersectus-gr.			8	8		16	5.3	3.3	0.3	8			2.7	1.9	0.1
Cricotopus tremulus-gr.	16				8	8	5.3	3.3	0.3	41	41	24	35.3	20.9	1.9
Cricotopus sp.	16		8				4.0	3.0	0.2	16	49		21.7	17.2	1.2
Heterotrissocladius changi				8			1.3	1.3	<0.1						
Nanocladius sp.	8	33		16	24	24	17.5	8.4	0.9	8	65	16	29.7	22.4	1.6
Psectrocladius sp.	16			8	16		6.7	4.0	0.3	8	41	33	27.3	17.7	1.5
Thienemanniella sp.	8			8	8		4.0	2.3	0.2	8			2.7	1.9	0.1
Synorthocladius sp.				8	8		2.7	1.9	0.1		8		2.7	1.9	0.1
Orthocladiini (undet.)				8		8	2.7	1.9	0.1		16		5.3	5.3	0.3
pupae	114		16	24		16	28.3	19.8	1.4	16		16	10.7	7.6	0.6
Total Chironomids	2042	842	816	1437	1035	1035	1183.7	514.9	60.4	358	956	620	644.7	398.1	35.7
AMPHIPODA															
Hyalell azteca	8	16	16		8	82	21.7	14.3	1.1	16	41	57	38.0	24.0	2.1
HYDRACARINA	8	8		41		8	10.8	7.2	0.5	8		8	5.3	3.7	0.3
SALIDAE						8	1.3	1.3	<0.1						
HYDRA	172	278	33	155	147		130.8	65.3	6.7	90	204	8	100.7	64.4	5.6

(continued).

APPENDIX A. (Continued).

Taxon	July									August					
	A-1	A-2	A-3	B-1	B-2	B-3	$\bar{X}$	S.E.	% T.A.	C-5	C-4	C-2	$\bar{X}$	S.E.	% T.A.
EPHEMEROPTERA															
Heptageniidae (undet.)	16		8	41	24	8	16.2	8.6	0.8	41	41	74	52.0	31.3	2.9
Heptagenia juno	8			49	8	49	19.0	11.7	1.0	8			2.7	2.7	0.1
Heptagenia maculipennis						16	2.7	2.6	0.1						
Heptagenia sp.		8	8				2.7	1.9	0.1						
Stenonema sp.															
Stenonema tripuctatum															
Paraleptophlebia sp.															
Baetis sp.	352	123	123	270	245	213	221	96.1	11.3	360	613	213	395.5	247.4	21.9
Caenis sp.												8	2.7	2.7	0.1
Total Ephemeroptera	376	131	139	360	277	286	261.5	113.8	13.3	409	654	295	452.7	275.3	25.0
TRICHOPTERA															
Hydropsychiidae (undet.)	114	24	57	106	123	16	73.3	34.7	3.7	91			30.0	30.0	1.6
Cheumatopsyche sp.	90	16	41	303	114	82	107.7	58.1	5.5	131	278	671	360.0	246	19.9
Symphitopsyche recurvata					16		2.7	2.6	0.1						
Mystacides sp.						8	1.3	1.3	<0.1						
Ceraclea sp. 1					8		1.3	1.3	<0.1		8		2.7	2.7	0.1
Ceraclea ancylus															
Agraylea sp.			8				1.3	1.3	<0.1	33	33	8	24.7	15.8	1.4
Ithytrichia clavata		8		8			2.7	1.9	0.1						
Hydroptilidae (undet.)										41			13.7	13.7	0.8
Total Trichoptera	204	48	106	417	261	106	109.3	92.5	9.7	296	319	679	431.3	268.8	23.8
OLIGOCHAETA															
Chaetogaster spp.	57	8		49	16		21.7	12.8	1.1	33	16	8	19.0	12.5	1.0
Stylaria lacustris	8	49	16	114	57	33	40.7	23.8	2.1	57	24	41	40.7	27.7	2.2
Pristina foreli	8			8		8	4.0	2.3	0.2						
Nais variabilis	8			74	82	33	32.8	19.3	1.7	8		16	8	6.5	0.4
Nais simplex	16			74	8	41	23.2	14.4	1.2	16		8	8	6.5	0.4
Nais behningi															
Total Oligochaeta	97	57	16	319	163	115	127.8	65.5	6.5	114	40	73	75.7	47.5	4.2
GASTROPODA															
Physella integra		49	8	90	8	65	36.7	20.3	1.9	16	57	65	46.0	29.3	2.5
SPHAERIIDAE												24	8.0	8.0	0.4
TOTAL ANIMALS	2907	1429	1134	2819	1794	1705	1959.2	847.4		1307	2271	1829	1087.3	1065.1	

APPENDIX B. Numbers of organisms per square meter for each sample at Waugoshance Point in October, 1978. Mean, standard error, and % of total animals is given for each taxon.

Taxon	Station																
	C-1	C-2	C-3	C-4	C-6a	A-1	A-2	B-1	B-2	B-3	B-4a	B-4b	B-5	B-6	$\overline{X}$	S.E.	% T. ANIM.
CHIRONOMIDAE																	
Nilotanypus sp.					8							8			1.1	0.8	<0.1
Thienemannimyia-gr.		16		24	24	8	41	57		8			33	24	16.8	6.4	1.6
Tanypodinae (undet.)							8								0.6	0.6	<0.1
Rheotanytarsus sp.	1186	303	1072	172	270	908	1415	229	270	8	49	605	1063	442	570.9	194.2	55.8
Micropsectra sp.					8	8	16	8	8		33				8.6	2.9	0.8
Tanytarsini (undet.)														8	0.6	0.6	<0.1
Phaenopsectra sp.				8		8		8							1.7	1.0	0.2
Parachironomus sp.												8			0.6	0.6	<0.1
Polypedilum scalaenum	8	114	24	57	65			33	16			16	24	8	26.1	10.9	2.6
Dicrotendipes sp.	8										8				1.1	0.9	0.1
Microtendipes sp.		8	8	8	8			65					8		7.5	4.8	0.7
Endochironomus sp.						8				16	16		16		4.0	2.1	0.4
Stictochironomus sp. 1													33		2.4	2.3	0.2
Chironomini (undet.)				8	8					8				8	2.3	1.1	0.2
Corynoneura sp.			8			16	74					8	8	8	8.7	5.5	0.8
Cricotopus festivellus-gr.							33						16		3.5	2.6	0.3
Cricotopus intersectus-gr.			8					24	8						2.9	1.9	0.3
Cricotopus tremulus-gr.									8						0.6	0.6	<0.1
Cricotopus sp.					8										0.6	0.6	<0.1
Nanocladius sp.					8		8		8						1.7	1.0	0.2
Orthocladius robacki								16							1.1	0.9	0.1
Parakiefferiella sp.		8													0.6	0.6	<0.1
Synorthocladius sp.			8				8	8							1.7	1.0	0.2
Orthocladiini (undet.)					8							8			1.1	0.9	0.1
Total Chironomids	1202	449	1128	277	415	956	1603	448	318	40	106	653	1201	498	663.9	215.3	64.9
EMPEDIDAE																	
Hemerodromia sp.					8	8	8	33	16						5.2	2.8	0.5
AMPHIPODA																	
Hyalella azteca	16	16	16	16	147	65	8	131			49	24	16	16	37.1	15.6	3.6
HYDRACARINA			8				8		8						1.7	1.0	0.2
GASTROPODA																	
Physella integra	33	8	16	24	41	16	41	16	8	24	24		8	33	20.9	6.5	2.0
HYDRA		82	41	8	33		155					49		16	27.4	13.6	2.7

(continued).

APPENDIX B. (Continued).

Taxon	Station C-1	C-2	C-3	C-4	C-6a	A-1	A-2	B-1	B-2	B-3	B-4a	B-4b	B-5	B-6	$\overline{X}$	S.E.	% T. ANIM.
EPHEMEROPTERA																	
Heptageniidae (undet.)	33	33	8			41	33	90	16		8	8		24	21.0	8.5	2.0
Heptagenia juno		33			16										3.5	2.6	0.3
Heptagenia maculipennis																	
Heptagenia sp.	16	8		33	8								65	16	10.4	5.5	1.0
Stenonema sp.					8			16					8		2.3	1.4	0.2
Stenonema tripunctatum							16		41						4.1	3.1	0.4
Paraleptophlebia sp.							8	90		8		8	8		8.7	6.5	0.8
Baetis sp.	33	8	16	24	41	41	98	131	8		24	24	24	57	37.8	13.8	3.7
Caenis sp.					8										0.6	0.6	<0.1
Total Ephemeroptera	82	82	24	57	81	82	155	327	65	8	32	40	105	97	88.4	31.0	8.6
TRICHOPTERA																	
Hydropsychiidae (undet.)	16	74	8	57	82	16	57	16		16		16	82	33	33.8	11.9	3.3
Cheumatopsyche sp.	33	65	24	82	82	24	98	82	16	8	8	147	262	82	72.4	26.2	7.1
Symphitopsyche recurvata	33	237	16	74	57		16			8		49	24	33	39.1	19.0	3.8
Mystacides sp.																	
Agraylea sp.			24	8		8	16								4.0	2.2	0.4
Ithytrechia sp.																	
Ceraclea sp. 1				8											0.6	0.6	<0.1
Ceraclea ancylus				8											0.6	0.6	<0.1
Total Trichoptera	82	376	72	237	221	48	187	98	16	32	8	212	368	148	150.4	50.9	14.7
PLECOPTERA																	
Isoperia sp.		16													1.1	1.1	0.1
CORIXIDAE								16							1.1	1.1	0.1
SPHAERIIDAE		16													1.1	1.1	0.1
OLIGOCHAETA																	
Chaetogaster spp.			49	16	24	33	16		24	16	16	8			14.4	5.4	1.4
Stylaria lacustris			8				8		8						1.7	1.0	0.2
Pristina foreli							8								0.6	0.6	<0.1
Nais variabilis					8						16			8	2.3	1.4	0.2
Nais simplex			16		8	8	33	8							5.2	2.8	0.5
Nais behningi		8													0.6	0.6	<0.1
Total Oligochaetes		8	73	16	40	41	65	8	32	16	32	8		8	24.8	8.9	2.4
Total Animals	1415	1053	1378	635	986	1216	2230	1077	463	120	251	986	1698	816	1023.1	1309.9	

APPENDIX C. Numbers of organisms per square meter for each sample at Cook riprap in August, 1978. Mean, standard error, and % of total animals is given for each taxon.

Taxon	Station 1	2	3	4	5	6	7	8	9	10	11	$\overline{X}$	S.E.	% T. ANIM.
CHIRONOMIDAE														
Psectrocladius simulans	311	286	401	401	401	433	294	318	188	581	172	344.3	35.1	22.6
Nanocladius sp.	8	8	16					8			8	4.4	1.3	0.3
Cricotopus bicinctus	8	24	8	8								4.4	2.0	0.3
Cricotopus festivellus-gr.									8			0.7	0.7	<0.1
Cricotopus tremulus-gr.														
Cricotopus sp.														
Parakiefferiella sp.		8										0.7	0.7	<0.1
Orthocladius (Ortho.) sp.														
Parachironomus sp.	8	8				24					16	5.1	2.1	0.3
Paracladopelma nereis		16										1.4	1.4	0.1
Polypedilum scalaenum		8		16		8					8	3.6	1.4	0.2
Saetheria tylus			16	41				8	8	8	8	8.1	3.2	0.5
Chironomus sp.			8									0.7	0.7	<0.1
Dicrotendipes sp.						8				8		1.4	1.4	0.1
Glyptotendipes sp.														
Chironomiini (undet.)														
Rheotanytarsus sp.	8						8				8	2.2	1.0	0.1
Micropsectra sp.						8						0.7	0.7	<0.1
Tanytarsini (undet.)														
Thienemannemyia-gr.	16	16	33	16	16	8	8	16	16	8	16	15	2.1	1.0
pupae	24		8	24	8	16		24		8	16	11.6	2.2	0.8
Total Chironomidae	383	374	490	506	425	505	310	375	220	613	252	404.8	35.7	26.6
AMPHIPODA														
Gammarus spp.		33	82	8	33	49		24		16	114	32.6	9.7	2.1
Hyalella azteca		8					33	16		24	114	17.7	9.4	1.2
Total Amphipoda		41	82	8	33	49	33	40		40	228	50.3	17.9	3.3
ISOPODA														
Asellus sp.							8			16	8	2.9	1.4	0.2
GASTROPODA														
Physella vinosa	16						33	16				5.1	3.0	0.3
EPHEMEROPTERA														
Stenonema puchellum	16				8				8			2.9	1.4	0.2
Stenonema sp.														
Heptagenia pulla														
Heptagenia sp.														
Heptageniidae (undet.)														
Total Ephemeroptera	16				8				8			2.9	1.4	0.2
TRICHOPTERA														
Symphitopsyche recurvata lt.	8											0.7	0.7	<0.1

(continued).

APPENDIX C. (Continued).

Taxon	Station 1	2	3	4	5	6	7	8	9	10	11	$\overline{X}$	S.E.	% T. ANIM.
Symphitopsyche recurvata dk.														
Cheumatopsyche sp.														
Hydropsychiidae (undet.)														
Trianodes sp.	8											0.7	0.7	<0.1
Mystacides sp.														
Ceraclea sp.														
Agraylea sp.														
Total Trichoptera	16											1.4	1.4	0.1
COLEOPTERA														
Hydroporous sp.														
Dubiraphia vittata														
Total Coleoptera														
BRYOZOA		P		P	P	P	P	P	P	P				
Cordylophora lacustris														
Hydra sp.	P	P	P	P	P	P	P	P	P	P	P			
HYDRACARINA	16	155	74	114	33	106	147	254	164	344	425	166.5	38.4	10.9
OLIGOCHAETA														
Aeolosomatidae					8							0.7	0.7	0.1
Chaetogaster spp.	1341	998	442	565	147	335	327	213	180	442	1407	581.5	137.6	38.2
Dero sp.				8		8						1.4	1.4	0.1
Nais alpena						8			16			2.2	1.4	0.1
Nais behningi		16										2.2	1.4	0.1
Nais bretscheri			25	41		65	24	74	16	16		23.7	6.5	1.6
Nais elinguis		8										0.7	0.7	0.1
Nais simplex		41	25		8			8				7.4	3.6	0.5
Nais variabilis	254	360	425	155	172	213	139	65	65	155	131	194.0	34.2	12.8
Nais sp.														
Ophidonais serpentina														
Pristina osborni														
Specarina josinae		8	49									5.2	4.2	0.3
Stylaria lacustris	123	147	106	106	82	65	32	33		24	8	66.0	13.7	4.3
Vejdovskyella intermedia		8										0.7	0.7	0.1
Immature with hair chaetae														
Immature without hair chaetae														
Enchytraidae														
Stylodrilus heringianus														
Total Naididae	1718	1586	1072	875	417	686	522	393	277	637	1554	885.2	157.6	58.2
Total Tubificidae														
Total Oligochaeta	1718	1586	1072	875	425	686	522	393	277	637	1554	885.2	157.6	58.2
Total Animals	2165	2156	1718	1503	924	1346	1053	1078	669	1650	2467	1520.8	173.4	

APPENDIX D. Numbers of organisms per square meter for each sample at Cook riprap in October, 1978. Mean, standard error, and % of total animals is given for each taxon.

Taxon	Station 1	2	3	4	5	6	7	8	9	10	11	12	13	14	$\overline{X}$	S.E.	% T. ANIM.
CHIRONOMIDAE																	
Psectrocladius simulans																	
Nanocladius sp.	8				8				8		8	8			2.9	0.8	0.8
Cricotopus bicinctus	24	8													2.3	1.6	0.6
Cricotopus festivellus-gr.						16									1.1	1.1	0.3
Cricotopus tremulus-gr.						8									0.6	0.5	0.2
Cricotopus sp.					16		8				8				2.3	1.1	0.6
Parakiefferiella sp.							8		8		8				1.7	0.8	0.4
Orthocladius (Ortho.) sp.			8												0.6	0.5	0.2
Parachironomus sp.									24						1.7	0.8	0.4
Paracladopelma nereis																	
Polypedilum scalaenum									8						0.6	0.5	0.2
Saetheria tylus		8			8	8									1.7	0.8	0.4
Chironomus sp.																	
Dicrotendipes sp.			8	8					8					8	2.3	0.8	0.6
Glyptotendipes sp.				8	8		16		24				8		4.6	1.7	1.2
Chironomiini (undet.)	8														0.6	0.5	0.2
Rheotanytarsus sp.	16	16		33		8	33	41	24		24				13.9	3.7	3.7
Micropsectra sp.				16	8					8					2.9	1.1	0.8
Tanytarsini (undet.)				8											0.6	0.5	0.2
Thienemannemyia-gr.	16	8	8		8	8								16	4.6	1.2	1.2
pupae		8											8		1.1	1.1	0.3
Total Chironomidae	72	48	24	73	56	48	65	41	104	8	48	16	16	24	45.9	6.9	12.1
AMPHIPODA																	
Gammarus spp.	24	41	131	49	139	122	41	82	57	16	16	33	57	16	58.9	11.1	15.6
Hyalella																	
Total Amphipoda	24	41	131	49	139	122	41	82	57	16	16	33	57	16	58.9	11.1	15.6
ISOPODA																	
Asellus sp.	8	8	8			16		16	8			16	57	8	10.4	3.4	2.7
GASTROPODA																	
Physella vinosa													8		0.6	0.5	0.2
EPHEMEROPTERA																	
Stenonema puchellum														8	0.6	0.2	0.2
Stenonema sp.	8		8					16				8	8		3.4	1.1	0.9
Heptagenia pulla				8					16						1.7	1.1	0.4
Heptagenia sp.		16	16	8	16	16							24	8	7.4	1.7	2.0
Heptageniidae (undet.)			8					8							1.1	0.7	0.3
Total Ephemeroptera	8	16	32	16	16	16		24	16			8	32	16	14.3	2.0	3.8
TRICHOPTERA																	
Symphitopsyche recurvata lt.	33	90	41	33	8	33	33	41	24	16	8	16	45	33	32.4	5.3	8.6

(continued).

APPENDIX D. (Continued).

Taxon	Station 1	2	3	4	5	6	7	8	9	10	11	12	13	14	$\overline{X}$	S.E.	% T. ANIM.
Symphitopsyche recurvata dk.	65	74	33	74	114	65	24	24	33	24	16	16	45	24	45.1	7.6	11.9
Cheumatopsyche sp.	16					8			8			16	8		4.0	1.3	1.1
Hydropsychiidae (undet.)	33	16	41	24	8	8	16				8				11	2.9	2.9
Trianodes sp.																	
Mystacides sp.									8						0.6	0.5	0.2
Ceraclea sp.	16	16	16		8	8	8		8		8			8	6.9	1.1	1.8
Agraylea sp.	8					8									1.1	0.7	0.3
Total Trichoptera	171	196	131	131	138	130	81	113	113	40	40	64	162	97	114.8	12.1	30.3
COLEOPTERA																	
Hydroporous sp.														8	0.6	0.5	0.2
Dubiraphia vittata			8												0.6	0.5	0.2
Total Coleoptera			8											8	1.2	0.7	0.3
BRYOZOA	P		P				P		P	P	P		P	P			
Cordylophora lacustris	P	P				P	P		P								
Hydra sp.	P	P	P	P	P	P	P	P	P	P	P	P	P	P			
HYDRACARINA	147	139	229	123	368	164	33	106	65	8	8	49	57	16	108	25.8	28.5
OLIGOCHAETA																	
Aeolosomatidae								8	8			57			5.2	3.7	1.4
Chaetogaster spp.	8	16		33			41	8	8			8			8.7	2.9	2.3
Dero sp.																	
Nais alpena																	
Nais behningi		16		8			16								2.9	24.2	0.8
Nais bretscheri																	
Nais elinguis	8														0.6	0.5	0.2
Nais simplex																	
Nais variabilis	8	41	16	49		8	8		24			8			11.6	3.6	3.1
Nais sp.		8				8									1.1	0.7	0.3
Ophidonais serpentina				8											0.6	0.5	0.2
Pristina osborni								8	8						1.1	0.7	0.3
Specarina josinae																	
Stylaria lacustris																	
Vejdovskyella intermedia																	
Immature with hair chaetae				16									8		1.7	1.1	0.4
Immature without hair chaetae			16				8	8							2.3	1.1	0.6
Enchytraidae	8	8				8									1.7	0.8	0.4
Stylodrilus heringianus							8								0.6	0.5	0.2
Total Naididae	24	81	16	98		16	65	24	48			73			31.8	7.3	8.4
Total Tubificidae							8	8					8		1.7	0.8	0.4
Total Oligochaeta	32	89	32	114		24	81	32	48			73	8		38.1	8.1	10.1
Total Animals	462	537	595	506	717	520	301	366	379	72	112	243	333	153	378.3	49.1	

APPENDIX E. Numbers of organisms per square meter for each sample at Cook Ponar during August, 1978. Mean, standard error, and % of total animals is given for each taxon.

Taxon	SDC. 5-1					NDC. 5-1					DC-1							
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	$\overline{X}$	SE	% T. ANIM.
CHIRONOMIDAE																		
Heterotrissocladius changi	41			41										20		6.8	3.5	0.2
Psectrocladius simulans		20	20	20			41			20		20	61			13.6	3.9	0.3
Cryptochironomus sp. 1									20		82					6.8	5.3	0.2
Cryptochironomus sp. 2	82	41	41	41	41	41	41	41	61		20	41	82	20	61	46.2	4.7	1.2
Cryptochironomus sp. 3				20	20						143	61	20	20		19.0	9.0	0.5
Cryptochironomus rolli											20					1.4	0.1	<0.1
Chironomus fluviatilis-gr.	4406	265	143	245	959		857	612	388	938		102	306	143	347	647.4	437.4	16.9
Chironomus anthracinus-gr.	204					306					82				20	40.8	21.7	1.1
Chironomus sp.	20				20	41				41						8.2	3.4	0.2
Polypedilum scalaenum	61		82	20					61		102	122	61	163	163	55.8	12.3	1.4
Saetheria tylus		204	224	265	122	612	326	612	326	571	347	245	428	306	204	319.6	39.7	8.3
Robackia demeijeri		326	530	408	224	367	347	469	388	592	490	388	469	367	326	379.4	24.7	9.9
Cladotanytarsus sp.	184	41		41	20				41	20		20		20		35.8	11.1	0.7
Monodiamesa tuberculata	41	20									20					5.4	2.8	0.1
Paracladopelma undine	20	20	20	163						41					20	19.0	10.0	0.5
Paracladopelma camptolabis-gr.			20													1.4	0.1	<0.1
Demicryptochironomus sp.											20		20			2.7	1.7	<0.1
Potthastia longimanus																		
pupae	61	61		102	82	20	122	102	61	41	82	61	61	41	82	65.3	6.9	1.7
Total Chironomidae	5120	988	1080	1346	1488	1407	1734	1836	1346	2264	1408	1060	1508	1100	1223	1661.2	261.8	43.3
AMPHIPODA																		
Pontoporeia hoyi	41	122	163	184	41	61	102	82	61	61	61	20	61	82	41	78.9	11.9	2.1
Gammarus sp.																1.4	0.1	<0.1
Total Amphipoda	41	122	163	184	41	61	102	82	61	61	61	20	61	82	41	80.3	11.9	2.1
GASTROPODA																		
Amnicola sp.																		
Valvata sincera																		
Somatogyrus sp.													20			1.4	0.1	<0.1
Total Gastropoda													20			1.4	0.1	<0.1
SPHAERIIDAE																		
Pisidium spp.	224	61	102	122	143	20	20	20	41	61	61	42	102	102	61	78.9	14.3	2.6
HYDRACARINA						20					41		41	41		9.5	3.8	0.2

(continued).

APPENDIX E. (Continued).

Taxon	SDC. 5-1					NDC. 5-1					DC-1							%
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	$\overline{X}$	SE	T. ANIM.
OLIGOCHAETA																		
Chaetogaster spp.	41	20	61	102	102				102	122				20	41	40.8	9.5	1.1
Dero																		
Nais variabilis	714	265	306	367	551	82	245	82	143	592	82	20	224	41	143	258.4	55.4	6.7
Piguetiella michiganensis	184	571	245	306	61	326	1020	408	857	1000	61	122	306	265	449	412.1	81.7	10.7
Pristina foreli																		
Specarina losinae	61															4.1	3.9	0.1
Stylaria lacustris	82	449	286	367	490		41		41	102	20		82		20	131.9	41.1	3.4
Uncinais uncinata	1510	428	408	469	918	122	367	20	224	286	41	20	245	306	449	387.6	99.5	10.1
Vejdovskyella intermedia	265															17.7	17.1	0.5
Aulodrilus pluriseta	41															2.7	2.6	<0.1
Limnodrilus augustipenis																		
Limnodrilus cervix			20													1.4	1.3	<0.1
Limnodrilus hoffmeisteri	41			20	41			20								8.2	3.4	0.2
Peloscolex freyi	163	41	204		306		20		41	20						53.0	22	1.4
Potamothrix moldaviensis	41		20				41			20						8.2	3.4	0.2
Potamothrix veldovskyi																		
Immature with hair chaetae	204	20			184				41							28.9	16.1	0.8
Immature without hair chaetae	1265	1122	530	769	1387		265	408	673			41	20	20	61	485.5	116.9	12.6
Enchytraidae																		
Stylodrilus heringianus						20										1.4	1.3	<0.1
Total Naididae	2857	1733	1306	1611	2122	530	1673	510	1367	2102	204	162	857	632	1102	1251.2	201.5	32.6
Total Tubificidae	1755	1183	774	816	1918		326	428	776	713		41	20	20	61	588.7	153.3	15.3
Total Oligochaeta	4612	2916	2080	2427	4040	550	1999	938	2143	2815	204	203	877	652	1163	1841.3	350.4	48.0
HIRUDINEA																		
Helobdella stagnalis																		
TURBELLARIA		82								20				20	20	9.5	5.2	0.2
Hydra				20	41		20			20	41		143		41	21.8	8.7	0.6
Total Animals	9997	4179	3425	4099	5753	2038	3875	2896	3591	7241	1836	1325	2752	1997	2549	3836.9	549.7	

APPENDIX F. Numbers of organisms per square meter for each sample at Cook Ponar during October, 1978. Mean, standard error, and % of total animals is given for each taxon.

Taxon	SDC. 5-1				NDC. 5-1				DC-1						
	A	B	C	D	A	B	C	D	A	B	C	D	$\bar{X}$	SE	% T. ANIM.
CHIRONOMIDAE															
Heterotrissocladius changi															
Psectrocladius simulans															
Cryptochironomus sp. 2	182	61		61			61	61					35.3	12.9	0.8
Cryptochironomus sp. 3	121		121		364	61	'61	61	364	61	303	121	136.3	32.8	3.2
Cryptochironomus rolli									61		61	242	30.3	18.0	0.7
Chironomus fluviatilis-gr.	727	909	1818	667	364			61	424	121	545	727	530.2	127.1	12.6
Chironomus anthracinus-gr.															
Chironomus sp.					61										
Polypedilum scalaenum					61	61							10.1	6.0	0.2
Saetheria tylus				61	1091	182	485	545		61		61	207.1	84.8	4.9
Robackia demeijeri					121		727	354				61	106.1	56.2	2.5
Cladotanytarsus sp.															
Monodiamesa tuberculata															
Paracladopelma undine															
Paracladopelma camptolabis-gr.	303	121		61					242		121	121	80.8	23.7	1.9
Demicryptochironomus sp.															
Potthastia longimanus						61	61	61					15.2	6.6	0.4
Total Chironomidae	1333	1091	1939	850	2062	365	1395	1153	1152		1091	1272	1157.1		27.5
AMPHIPODA															
Pontoporeia hoyi		242									61	121	35.3	18.8	0.8
Hyalella azteca								61					5.1	4.7	0.1
Total Amphipoda		242						61		182	61	121	40.4	24.7	1.0
GASTROPODA															
Amnicola sp.									61				5.1	4.7	0.1
Somatogyrus sp.															
Total Gastropoda									61				5.1	4.7	0.1
SPHAERIIDAE															
Pisidium spp.	121	121	61			303		121	121		61		65.6	21.8	1.6
HYDRACARINA						121			61				15.2	9.6	0.4

(continued).

APPENDIX F. (Continued).

Taxon	SDC. 5-1 A	B	C	D	NDC. 5-1 A	B	C	D	DC-1 A	B	C	D	$\bar{X}$	SE	% T. ANIM.
OLIGOCHAETAE															
<u>Chaetogaster</u> spp.	61						182						126.2	68.5	3.0
<u>Dero</u>													5.1	4.7	0.1
<u>Nais variabilis</u>	242	242	485	424	4606	2060	788				61		903.9	354.7	21.5
<u>Piguetialla michiganensis</u>	2303	667	364	61	848	2666	1212	1697	303	182	121	424	903.9	243.9	21.5
<u>Pristina foreli</u>					121	2000		242					196.9	150.4	4.7
<u>Specarina josinae</u>															
<u>Stylaria lacustris</u>						182							20.2	13.5	0.5
<u>Uncinais uncinata</u>	121	61	61	61		364	182	303		242	121		126.2	28.5	3.0
<u>Vejdovskyella intermedia</u>						121							10.1	9.2	0.2
<u>Aulodrilus pluriseta</u>								61					5.1	4.7	0.1
<u>Limnodrilus augustipenis</u>															
<u>Limnodrilus cervix</u>															
<u>Limnodrilus hoffmeisteri</u>															
<u>Peloscolex freyi</u>															
<u>Potamothrix moldaviensis</u>						61							5.1	4.7	0.1
<u>Potamothrix vejdovskyi</u>					61	61		61					15.2	6.6	0.4
Immature with hair chaetae								242					20.2	18.5	0.5
Immature without hair chaetae	788	61	61		667	1394	242	1697		121	61		242.2	150.7	10.1
Enchytraidae							61						5.1	4.7	0.1
<u>Stylodrilus heringianus</u>								61					5.1	4.7	0.1
Total Naididae	2727	970	910	546	6000	7393	2364	5090	303	424	303	424	2287.8	100.1	54.4
Total Tubificidae	788	61	61		728	1516	242	2000		121	61		464.8	238.9	11.0
Total Oligochaeta	3515	1031	971	546	6728	8909	2667	7151	303	545	364	424	2762.8	1225.5	65.6
HIRUDINEA															
<u>Helobdella stagnalis</u>								61					5.1	4.7	0.1
TURBELLARIA	364		121	61	121	242	61	121				61	95.9	26.2	2.3
<u>Hydra</u>						61	485						45.4	36.6	1.1
TOTAL ANIMALS	5333	2485	3092	1457	8911	1001	4608	8729	1698	788	1516	1878	420.8	1393.4	